

DESIGN PRINCIPLES FOR VISUAL ANALYTICS IN OPERATIONS

MATT CONLEN CHELLY JIN SARA STALLA

SCOTT DAVIDOFF MAGGIE HENDRIE HILLARY MUSHKIN SANTIAGO LOMBEYDA

SOLS 4833 - 4833

YPR 123, 21, 1

GTP

EMP

128



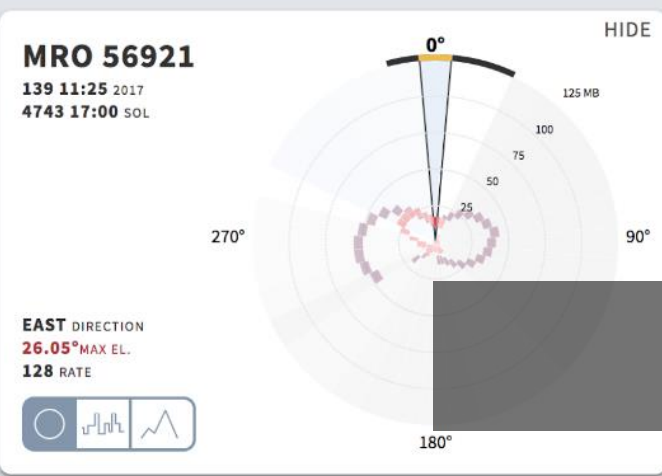
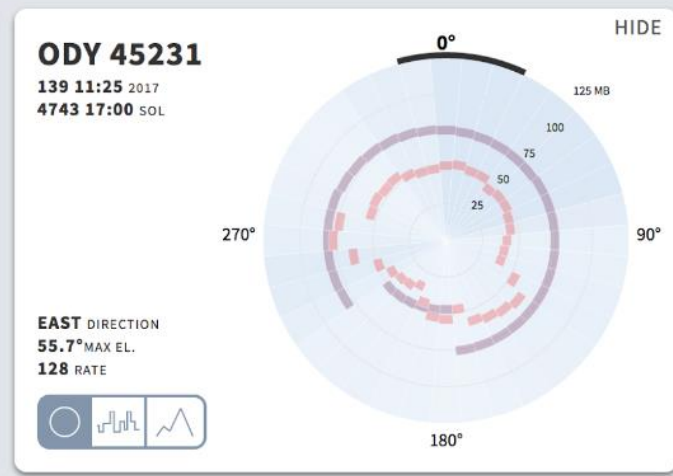
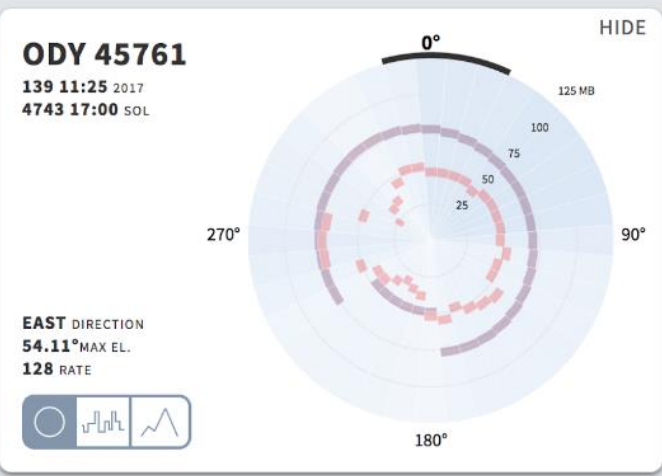
CLEAR

OVERPASS

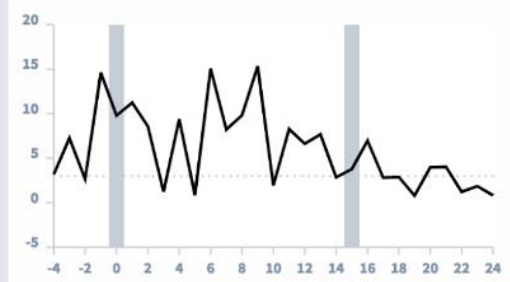
SEND



0 130 MB



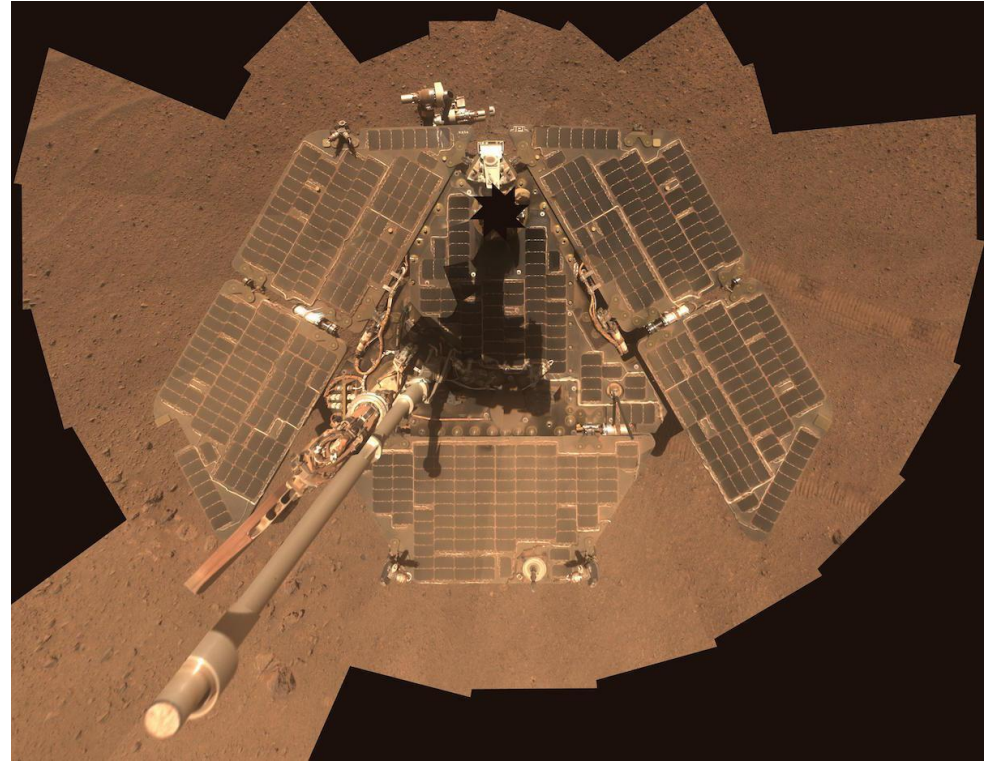
MERIDIAN



Mars Exploration Rover (MER) **OPPORTUNITY**

Launched in 2003,
on Mars since 2004

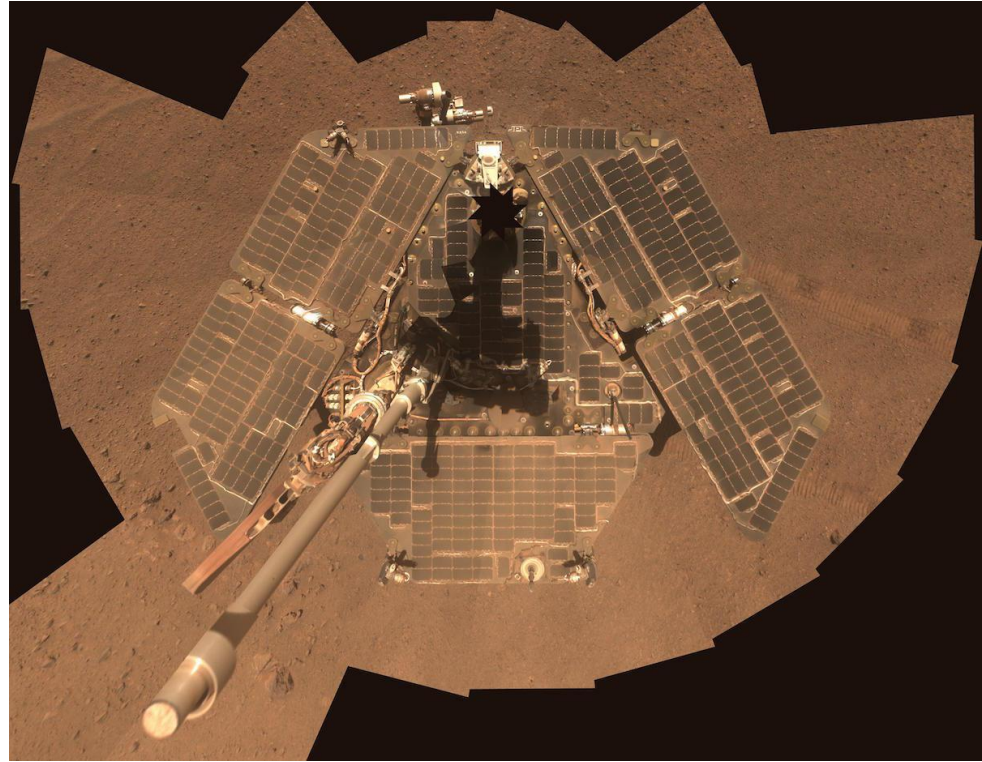
Several cameras
onboard spectrometer
microscopic imager



Mission was meant to last 90 days,
certain tools not developed for long
term management

ROVER LIMITATIONS

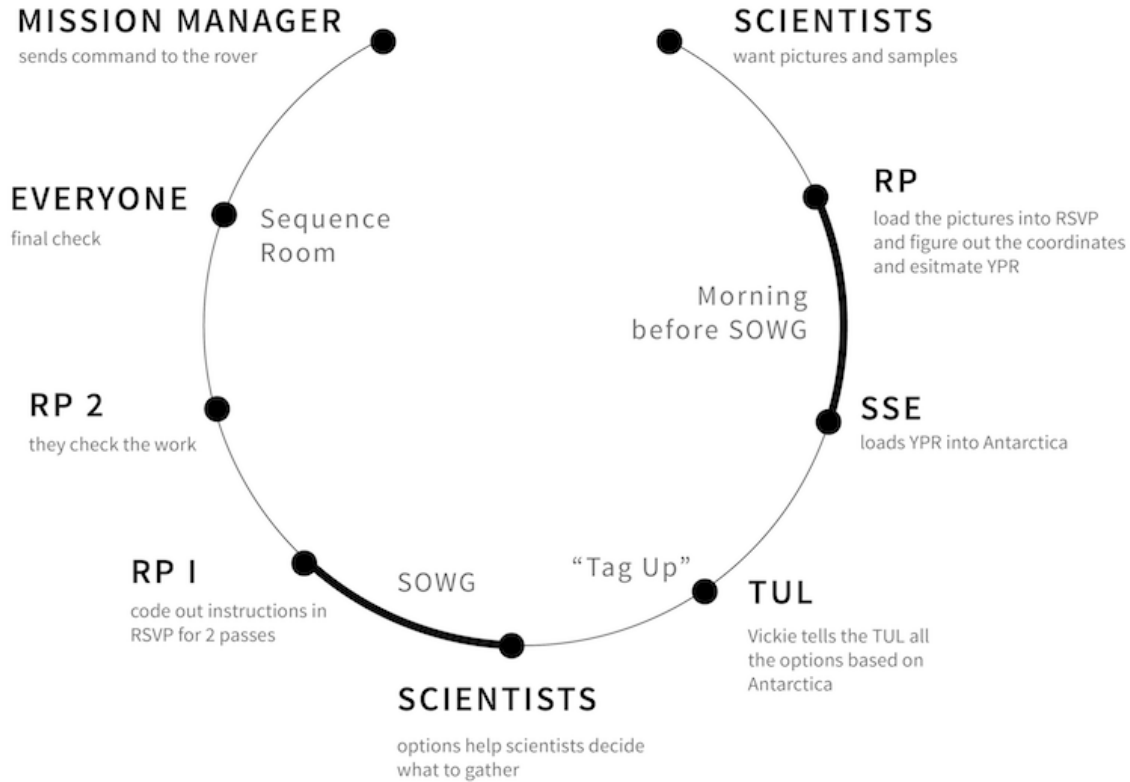
steering, driving, memory is wiped
every night

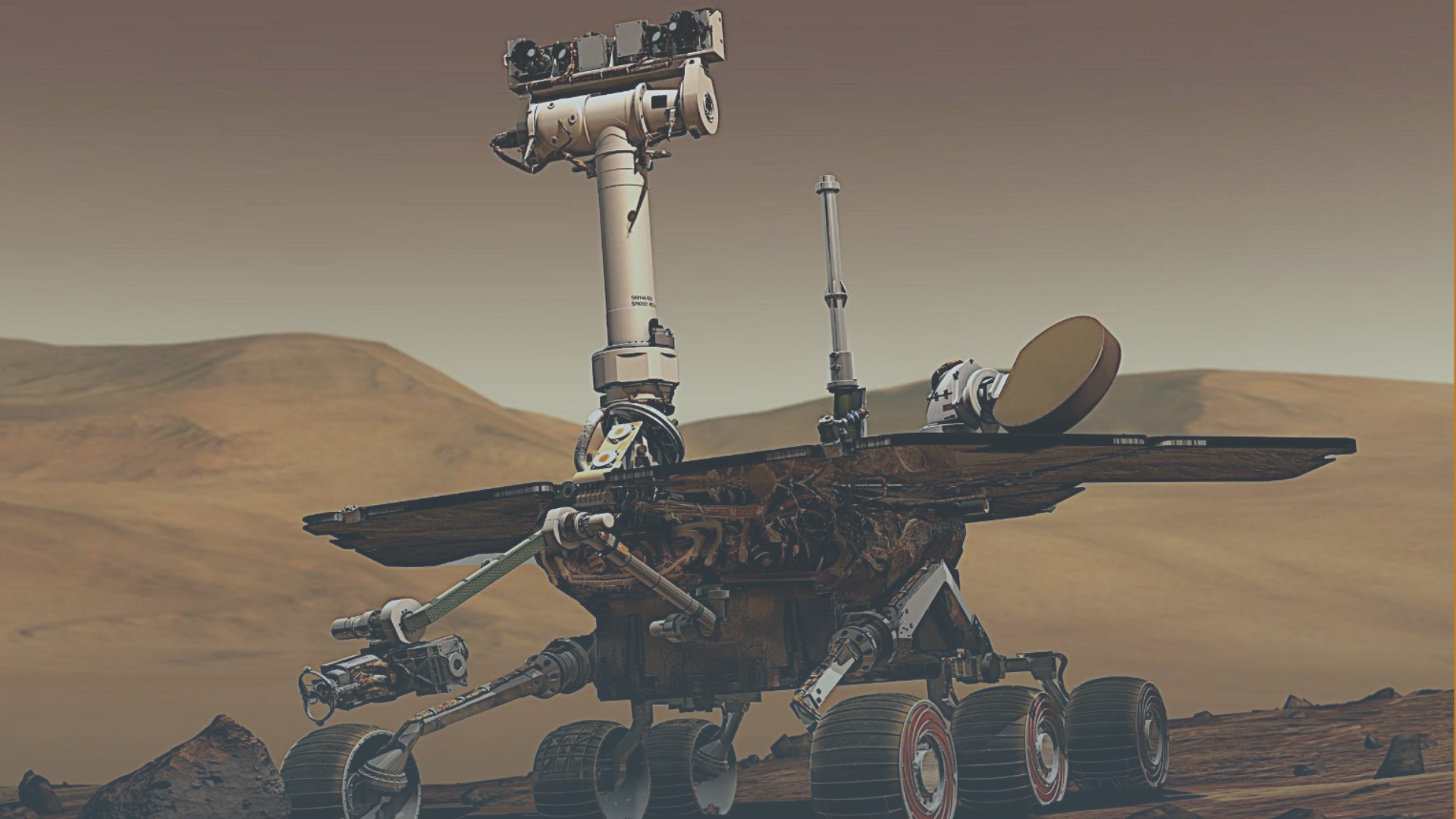


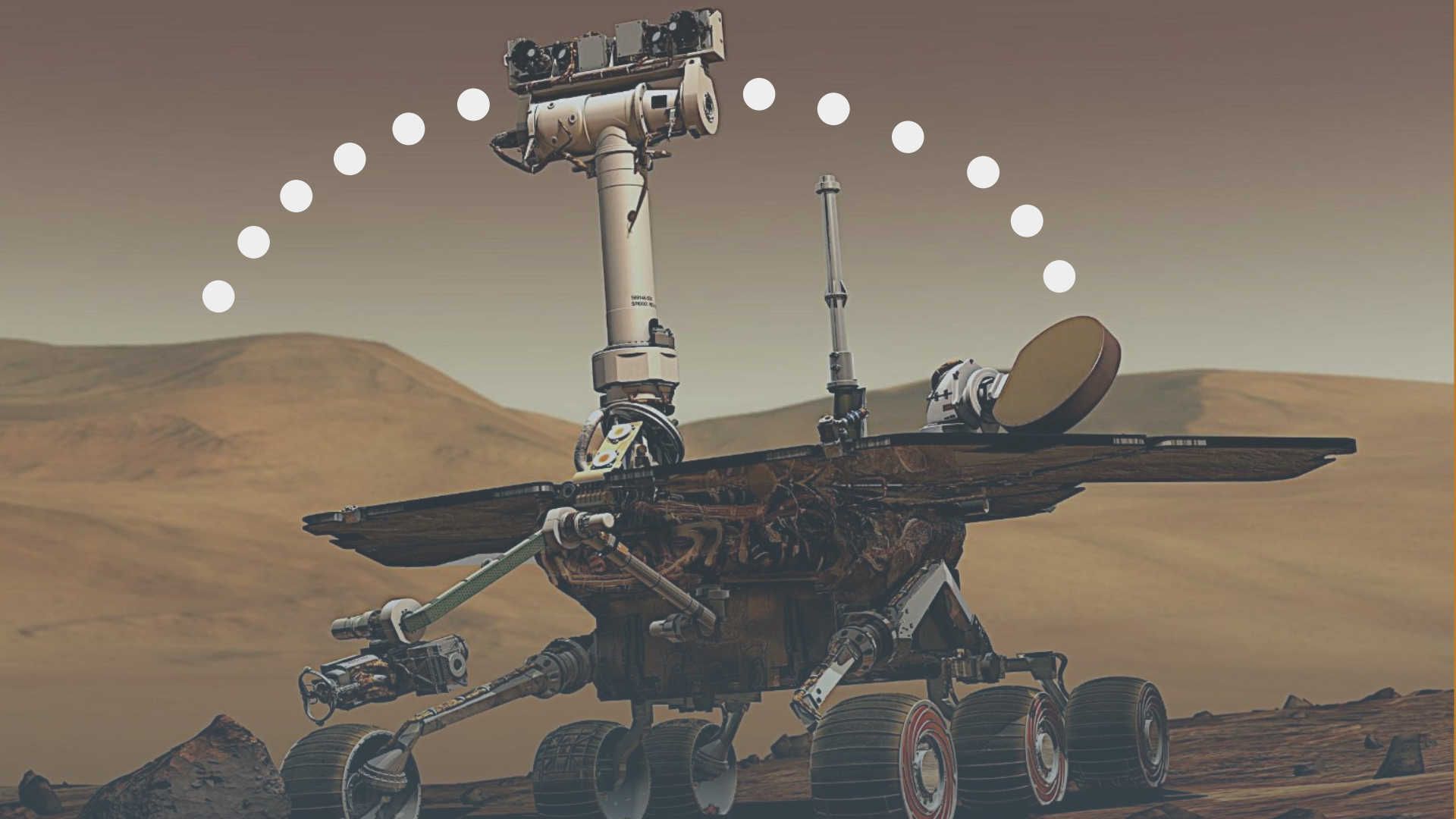
PROBLEM STATEMENT

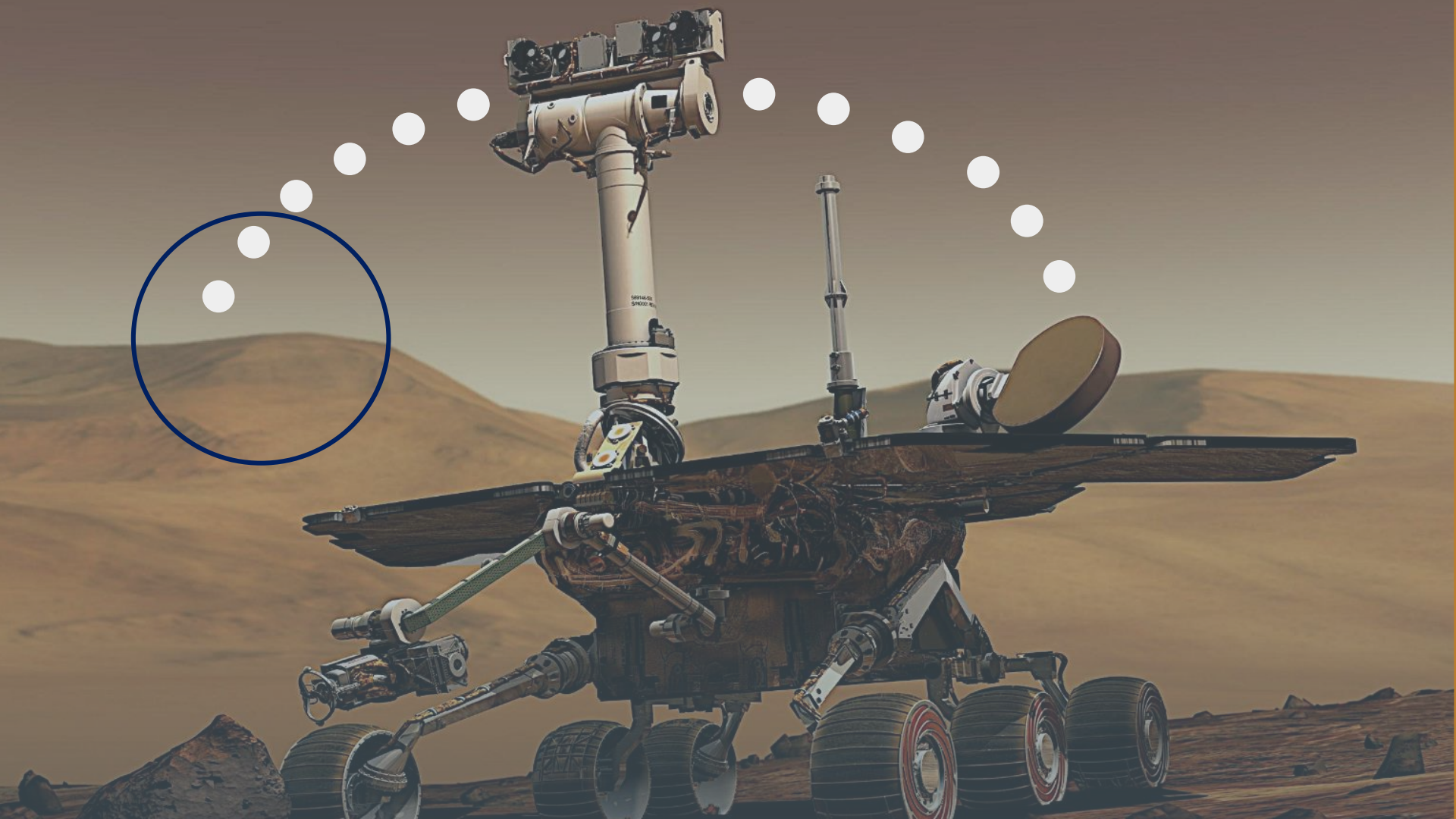
Spacecraft Systems Engineers (SSEs) need to prediction how much data can be transferred from the rover to an overpassing satellite in order to:

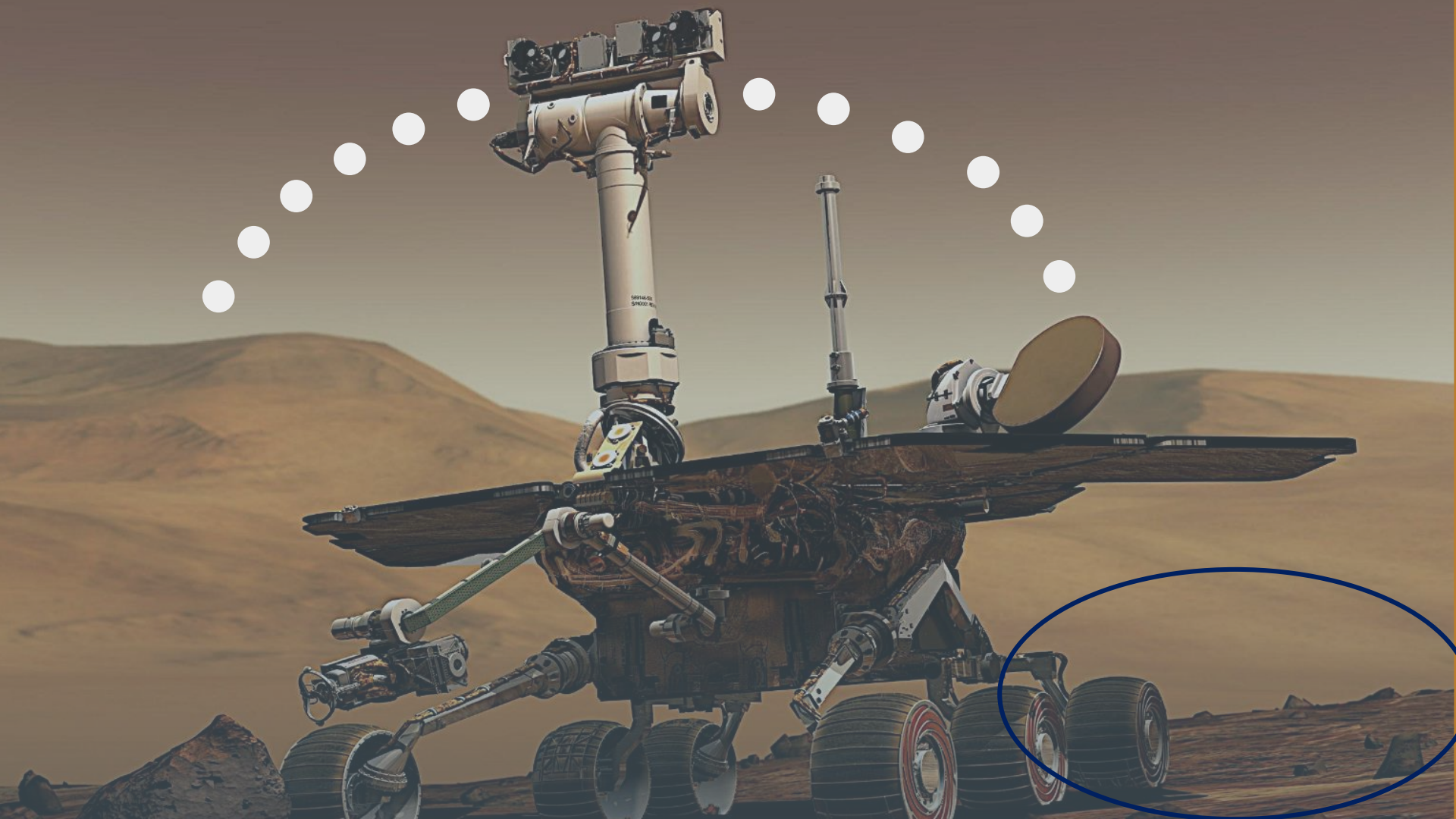
- 01 Provide scientists with an estimate of available data transfer
- 02 Recommend the heading at which a rover should end its path to achieve a high level of data transfer.

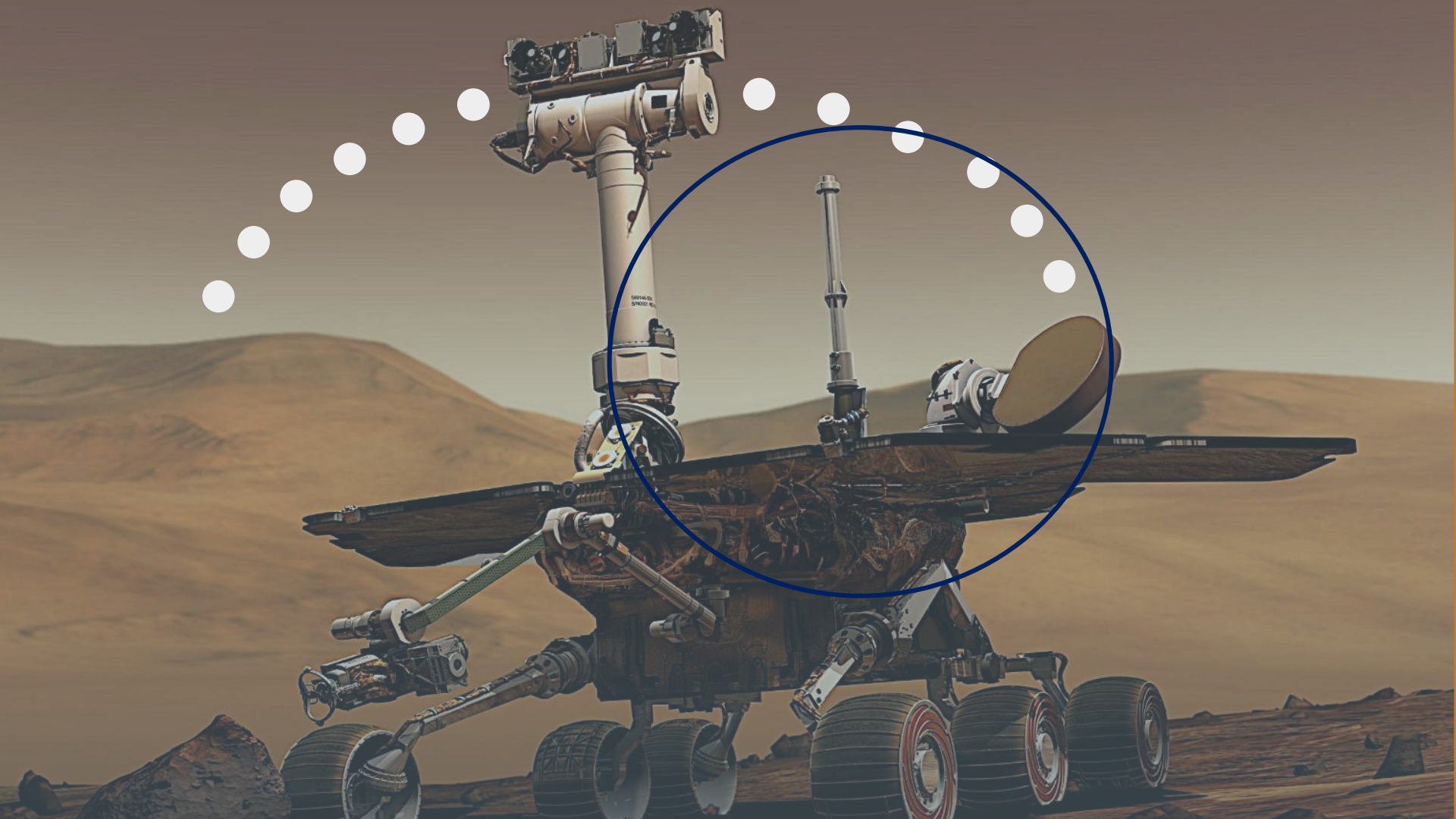








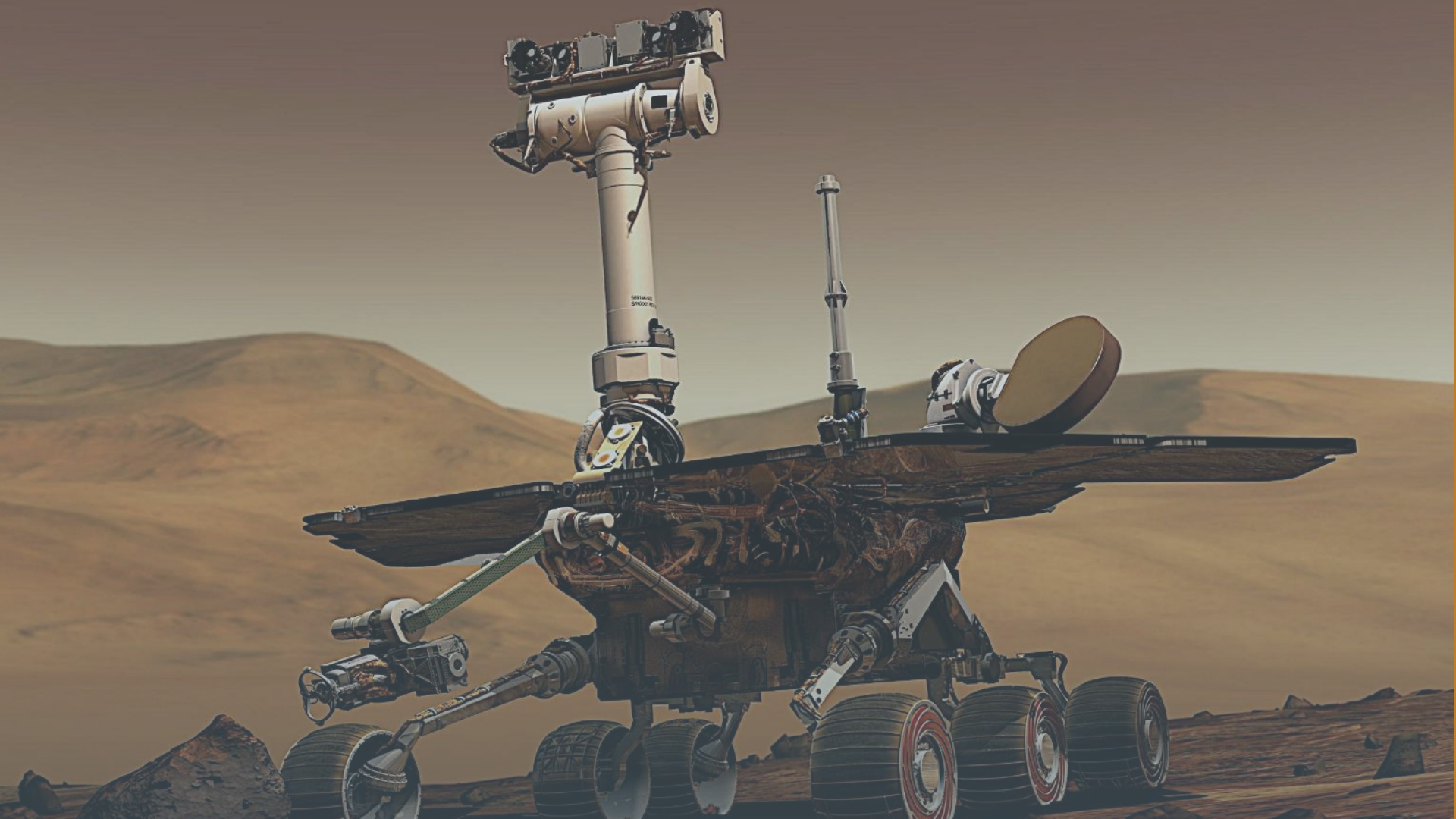




WHEN MAKING DECISIONS ABOUT DATA TRANSFER, **SSEs MUST CONSIDER**

01 The ability of the rover
to link with the orbiter
Link Margin

02 The total amount of data
that can be transferred
GTP EMP



“Currently our method of evaluating our heading choices is to open all of the plots, on different computers or windows, and to examine each one, moving them around the screen to compare next to each other.

Sometimes we will even print out some of the plots and hold layered paper up to the light to compare them together.”

* * * W A R N I N G * * *

You are connected to a Jet Propulsion Laboratory machine

Property of the
UNITED STATES GOVERNMENT

This computer is funded by the United States Government and operated by the California Institute of Technology in support of ongoing U.S. Government programs and activities. If you are not authorized access to this system, disconnect now. Users of this system have no expectation of privacy. By continuing, you consent to your keystrokes and data content being monitored.

Unauthorized Access is a violation of U. S. Federal Law.

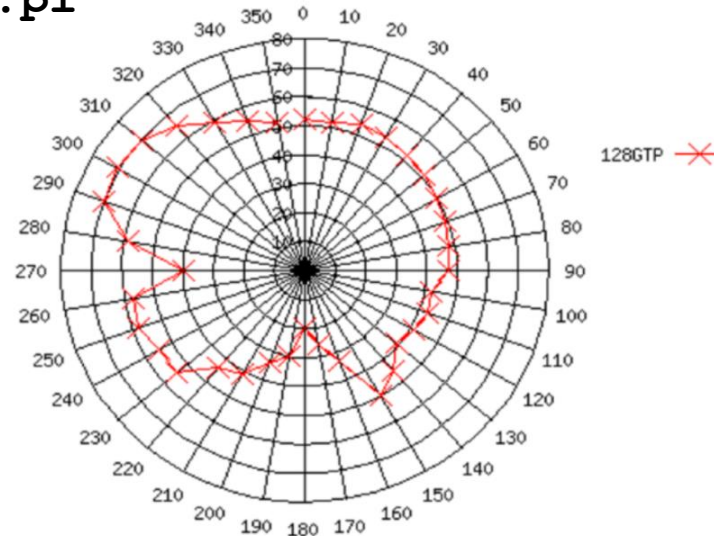
*** WARNING ***
You are connected to a Jet Propulsion Laboratory machine

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This computer is funded by the United States Government and operated by the California Institute of Technology in support of ongoing U.S. Government programs and activities. If you are not authorized access to this system, disconnect now. Users of this system have no expectation of privacy. By continuing, you consent to your keystrokes and data content being monitored.

Unauthorized Access is a violation of U. S. Federal Law.

./ANTARCTICA.pl

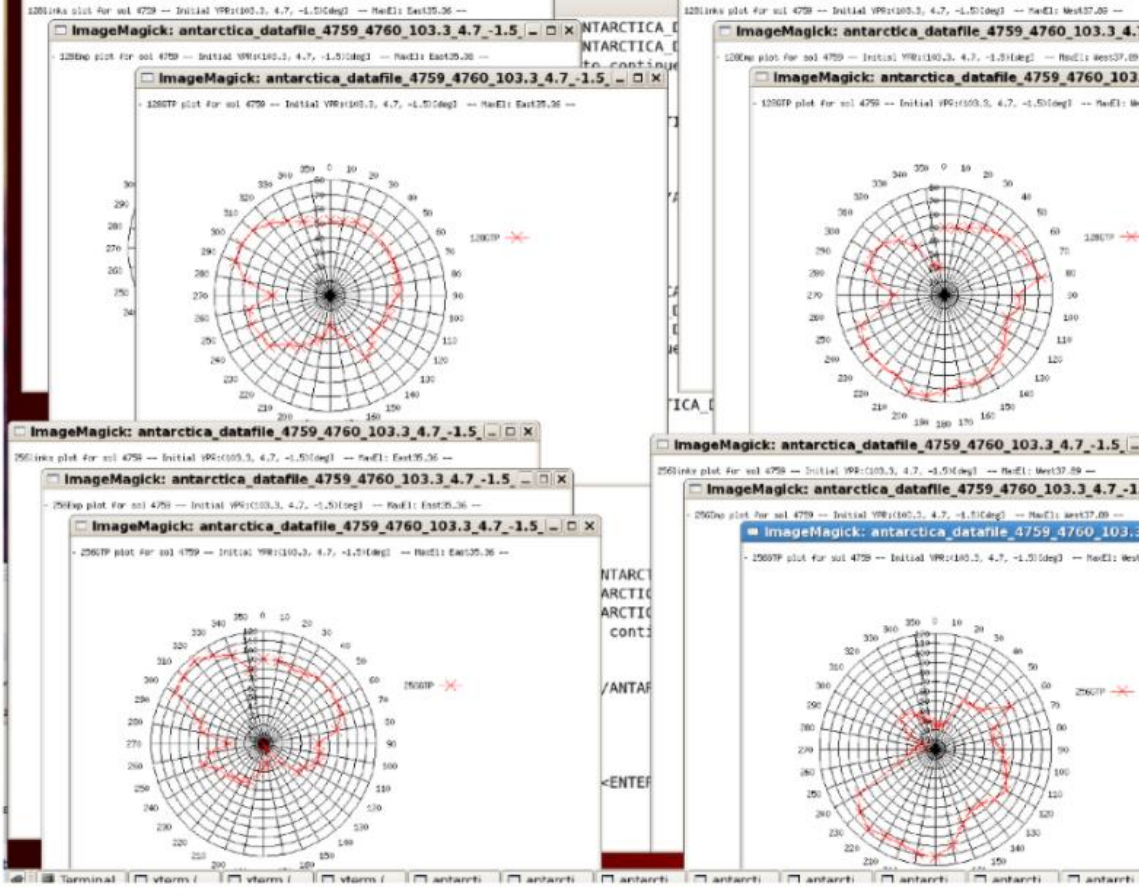
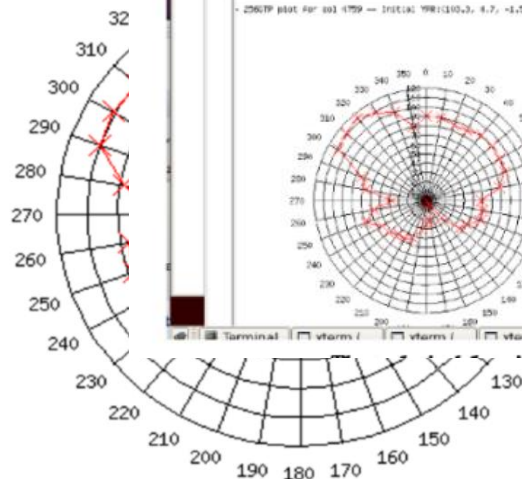


You are conr

This computer is fund
California Institut
programs and act
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of privacy. E

Unauthorized

./ANTARCTICA.pl

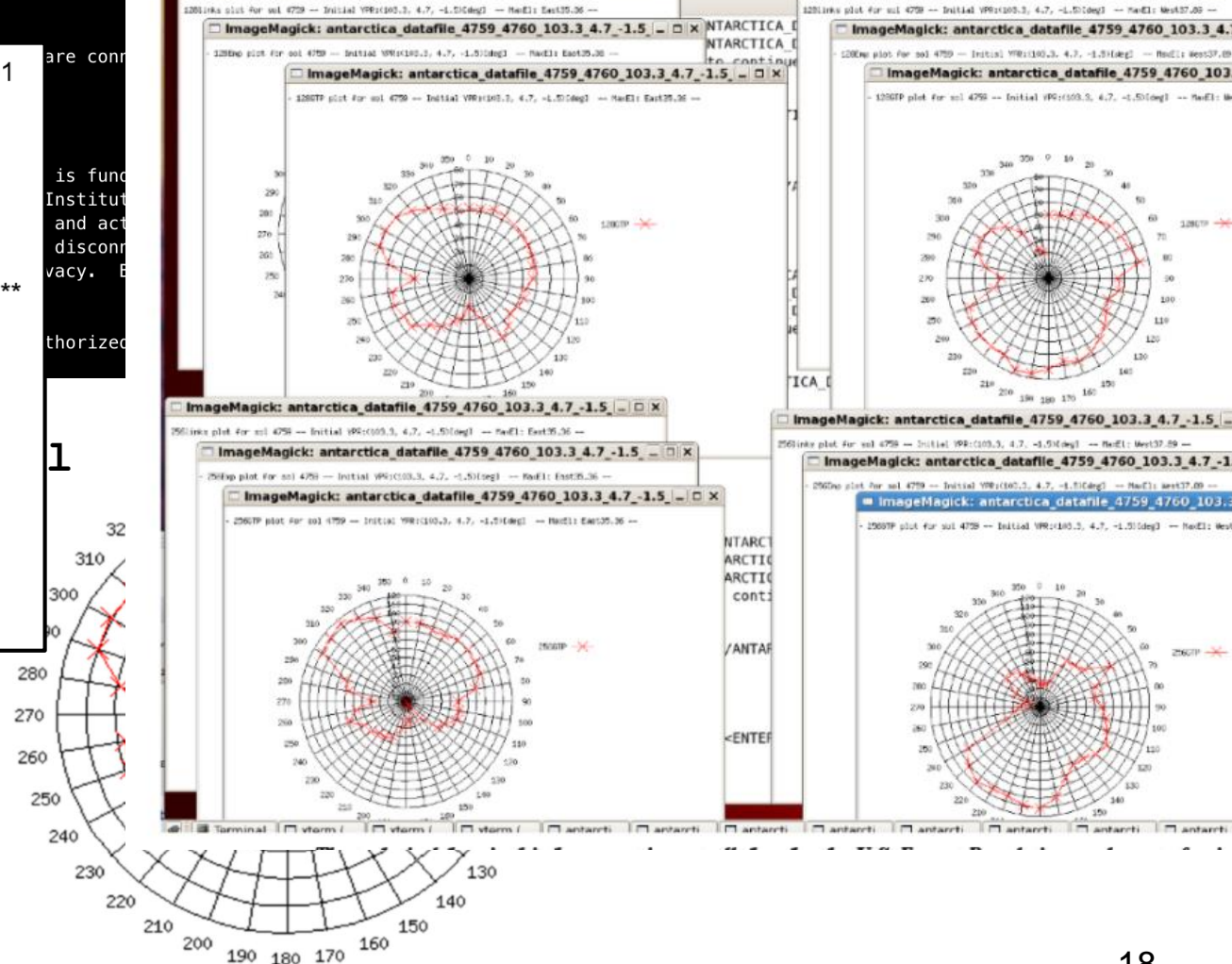


thorized

128k DV: 52.64 (Mbits) Link (dB): 12.83 ***
256k DV: 80.46 (Mbits) Link (dB): 8.932

128k DV: 92.45 (Mbits) ***
256k DV: 119.33 (Mbits)

Historically, for this yaw the 128k Empirical predicts have been more accurate.
Historically, for this yaw the 256k Empirical predicts have been more accurate.



Predicts for 47591 ODY_MRB_2017_165_01

Predicts for 47591 ODY_MRB_2017_165_01

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Predicts for 47591 ODY_MRB_2017_165_01

yaw = 350.00, pitch = -3.24, roll = -3.72

Startran: 2017-165T04:21:29 (UTC) SOL

4759 17:26:58 (LST)

Pass is East, with a max el of 35.36 (deg)

GTP Predicts*****

128k DV: 52.64 (Mbits) Link (dB): 12.83 ***

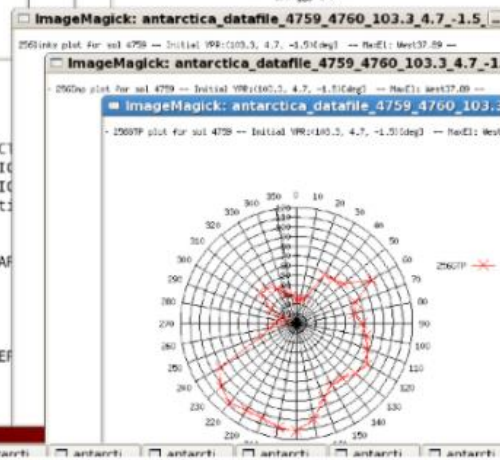
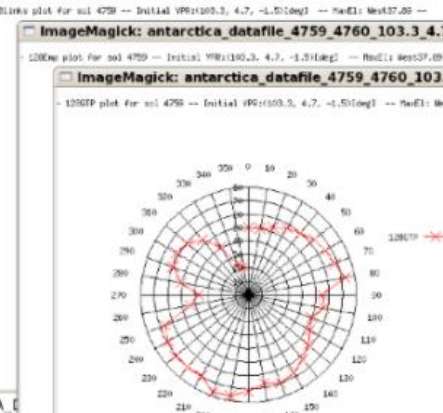
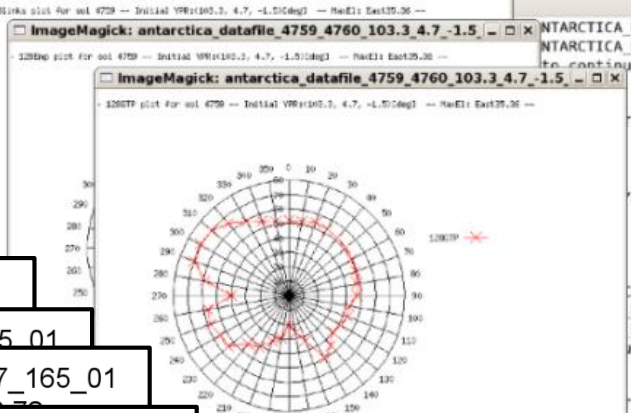
256k DV: 80.46 (Mbits) Link (dB): 8.932

Empirical Predicts***

128k DV: 92.45 (Mbits) ***

256k DV: 119.33 (Mbits)

Historically, for this yaw the 128k Empirical



pred



Predicts for 47591 ODY MRB 201

Predicts for 47591 ODY MRB

Predicts for 47591 ODY MRB

Predicts for 47591 ODY MRB

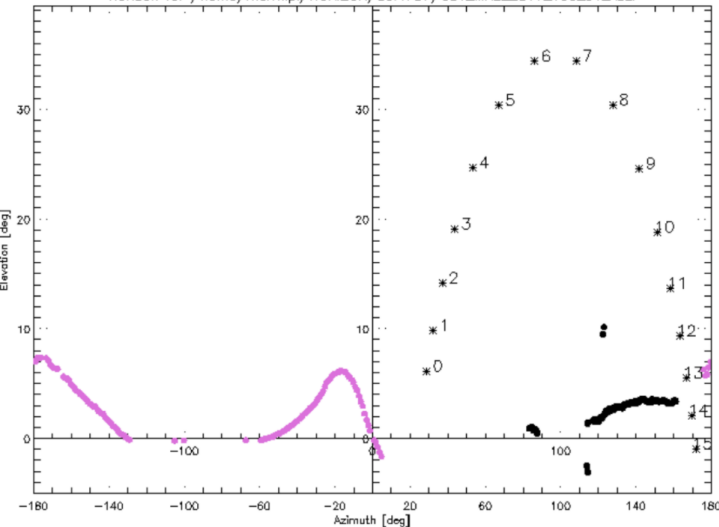
Predicts for 47591 ODY MRB

Predicts for 47591 ODY MRB

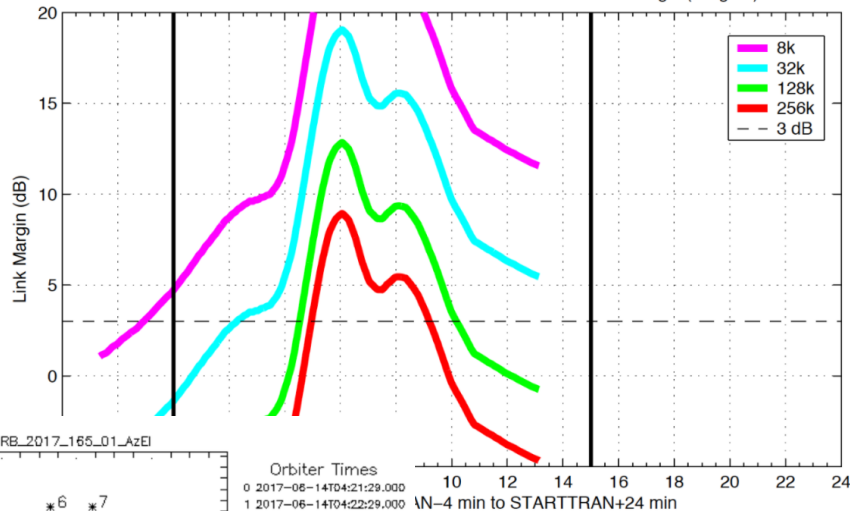
Predicts for 47591 ODY MRB

Predicts for 47591 ODY MRB

Predicts for 47591 ODY MRB



MER-B ODY STARTTRAN: 2017-165T04:21:00 Return Link Margin (1 sigma)



Orbiter Times

0 2017-06-14T04:21:29.000
1 2017-06-14T04:22:29.000
2 2017-06-14T04:23:29.000
3 2017-06-14T04:24:29.000
4 2017-06-14T04:25:29.000
5 2017-06-14T04:26:29.000
6 2017-06-14T04:27:29.000
7 2017-06-14T04:28:29.000
8 2017-06-14T04:29:29.000
9 2017-06-14T04:30:29.000
10 2017-06-14T04:31:29.000
11 2017-06-14T04:32:29.000
12 2017-06-14T04:33:29.000
13 2017-06-14T04:34:29.000
14 2017-06-14T04:35:29.000
15 2017-06-14T04:36:29.000

MRB_2017_165_01

roll = -3.72

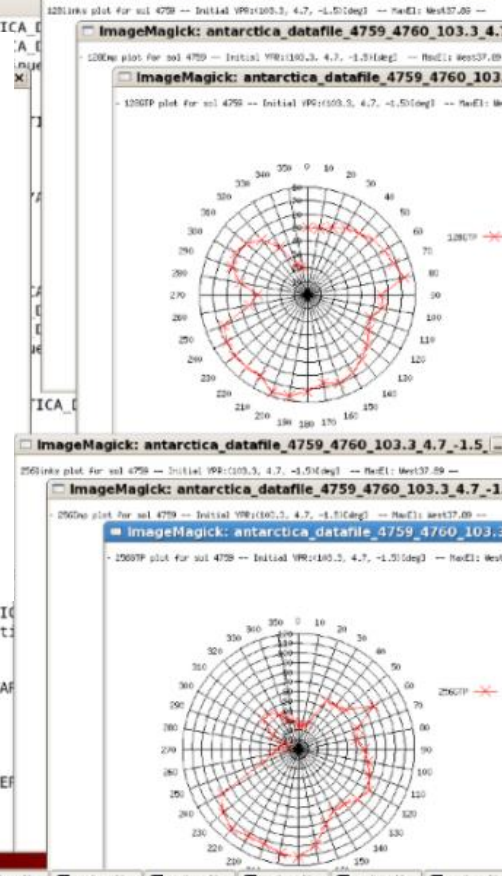
:29 (UTC) SOL

el of 35.36 (deg)

ink (dB): 12.83 ***

ink (dB): 8.932

*



Predicts for 47591 ODY_MRB_201

Predicts for 47591 ODY_MRB

Predicts for 47591 ODY_MF

Predicts for 47591 ODY

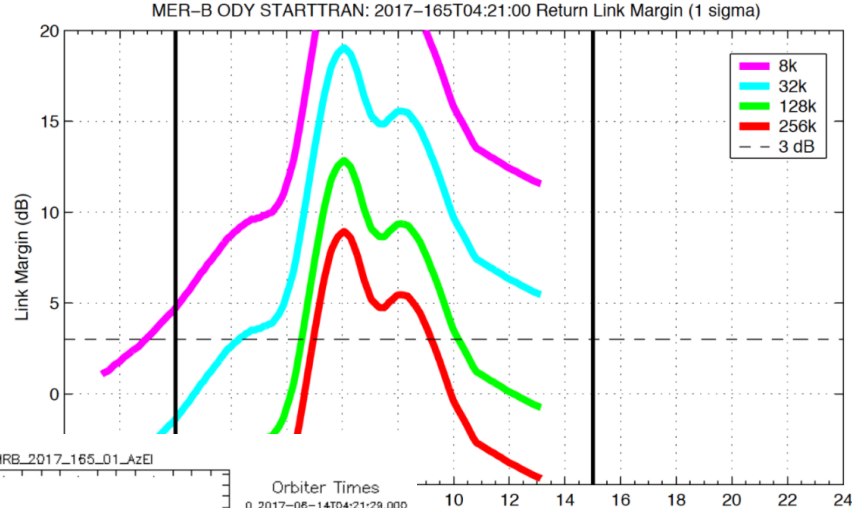
Predicts for 47591

Predicts for 47

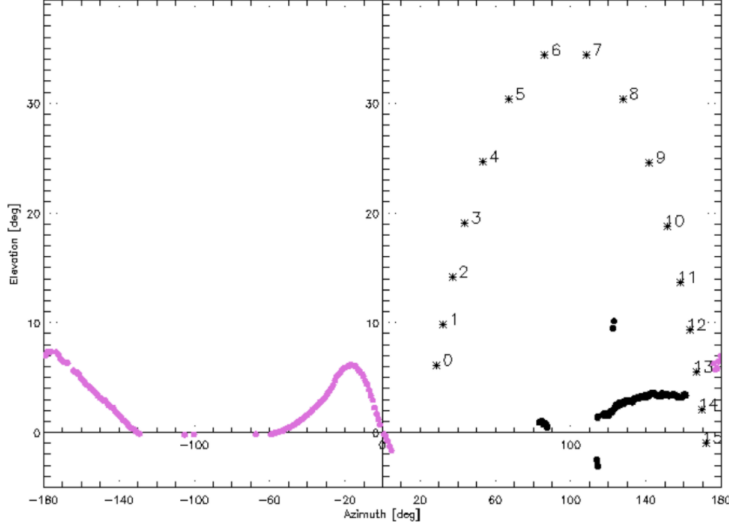
Predicts for

Predict

Predict



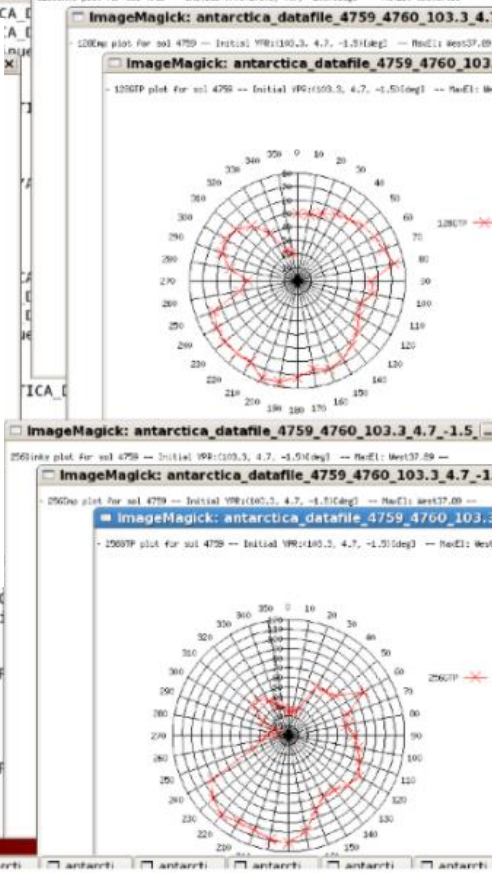
Horizon for /home/memipi/HORIZON/Sol4757/ODY_MRB_2017_165_01_AzEl



Orbiter Times
0 2017-06-14T04:21:29.000
1 2017-06-14T04:22:29.000
2 2017-06-14T04:23:29.000
3 2017-06-14T04:24:29.000
4 2017-06-14T04:25:29.000
5 2017-06-14T04:26:29.000
6 2017-06-14T04:27:29.000
7 2017-06-14T04:28:29.000
8 2017-06-14T04:29:29.000
9 2017-06-14T04:30:29.000
10 2017-06-14T04:31:29.000
11 2017-06-14T04:32:29.000
12 2017-06-14T04:33:29.000
13 2017-06-14T04:34:29.000
14 2017-06-14T04:35:29.000
15 2017-06-14T04:36:29.000

MRB_2017_165_01
 :4, roll = -3.72
 :29 (UTC) SOL
 al of 35 36 (deg)

: (



WHAT ARE THE PROBLEMS WITH THE CURRENT APPROACH

01

TIME CONSUMING

02

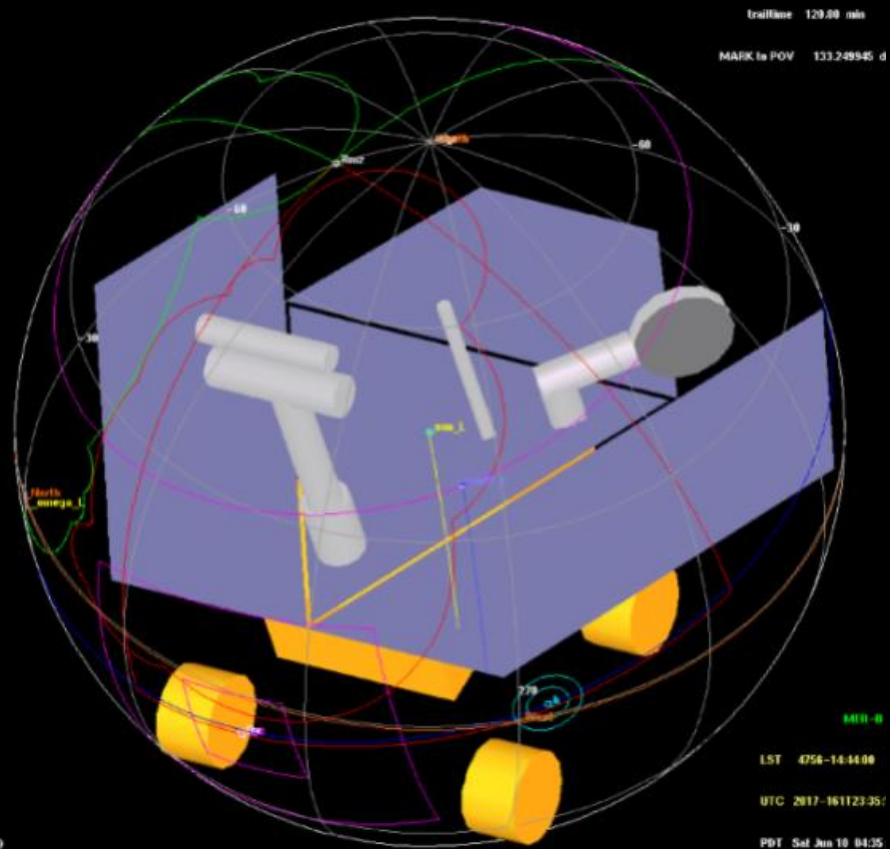
DECENTRALIZED

03

HARD TO COMMUNICATE

WHAT ARE THE PROBLEMS
WITH THE CURRENT APPROACH

SERIOUS REPERCUSSIONS FOR MISTAKES



PROBLEM STATEMENT

Spacecraft Systems Engineers (SSEs) need to prediction how much data can be transferred from the rover to an overpassing satellite in order to:

- 01 Provide scientists with an estimate of available data transfer
- 02 Recommend the heading at which a rover should end its path to achieve a high level of data transfer.

MISSION MANAGER

sends command to the rover

SCIENTISTS

want pictures and samples

EVERYONE

final check

Sequence
Room

RP

load the pictures into RSVP
and figure out the coordinates
and estimate YPR

Morning
before SOWG

RP 2

they check the work

SSE

loads YPR into Antarctica

RP 1

code out instructions in
RSVP for 2 passes

SOWG

"Tag Up"

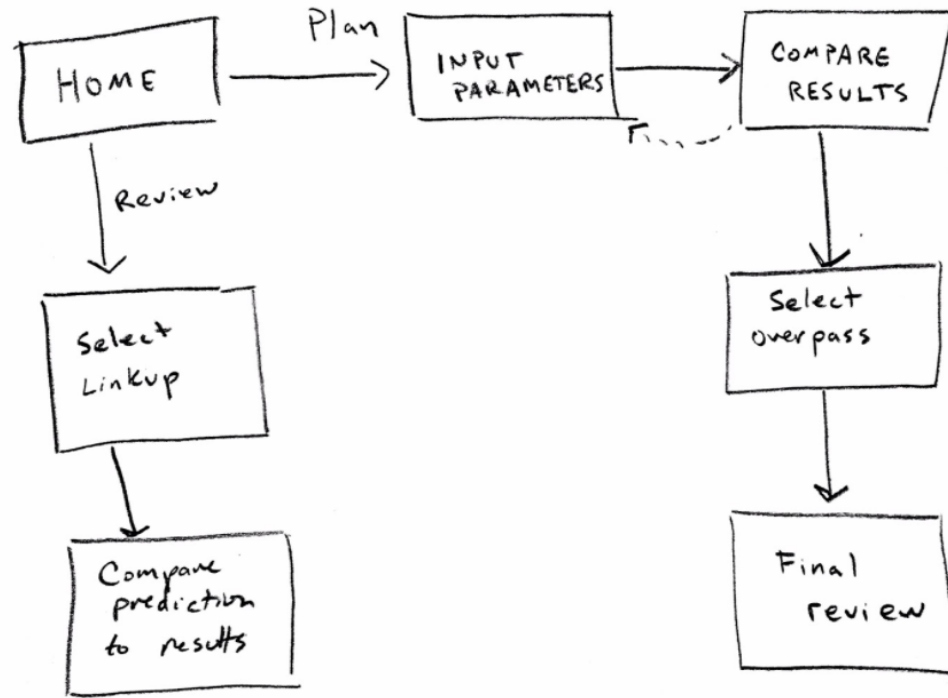
TUL

Vickie tells the TUL all
the options based on
Antarctica

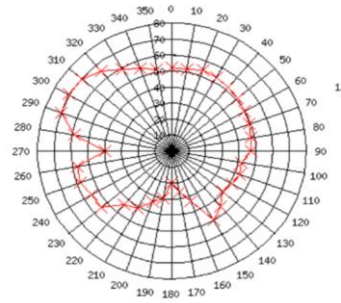
SCIENTISTS

options help scientists decide
what to gather

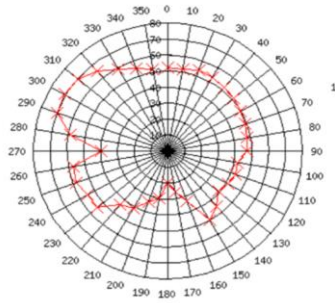
SYSTEM WORKFLOW



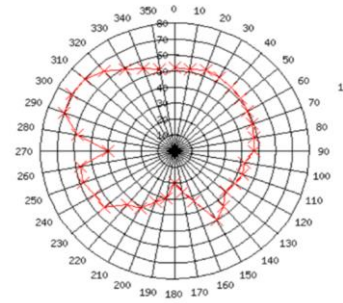
REDESIGNING THE PLOTS



GTP

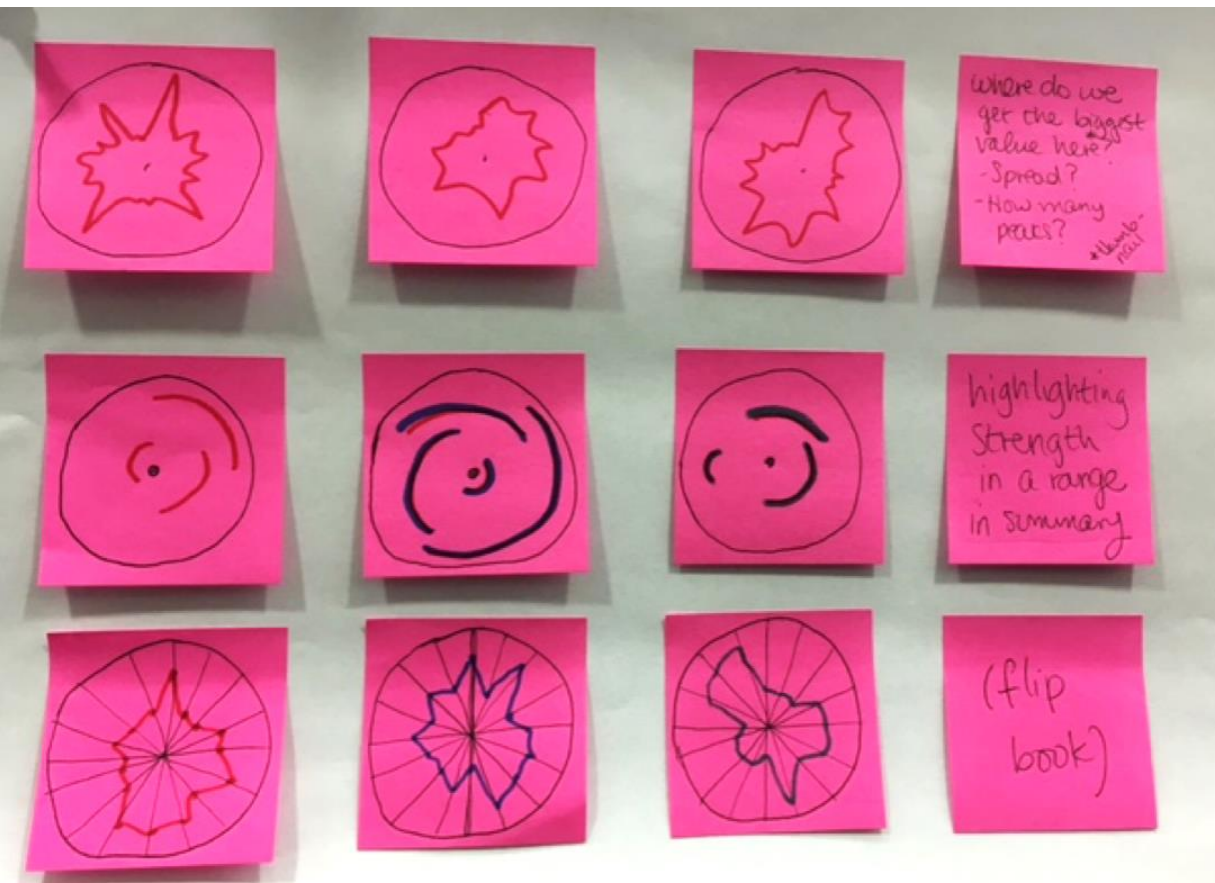


EMP



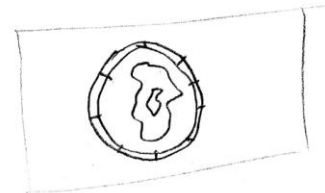
LINK
MARGIN

REDESIGNING THE PLOTS

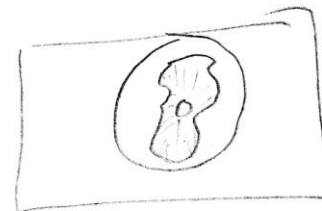


Small Overview Chart Ideas

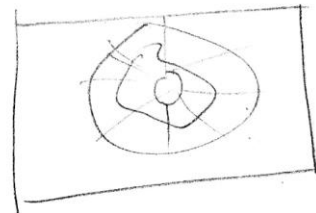
Color only around ring



Color clipped by lines



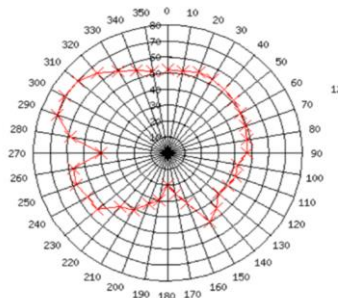
softer coloring



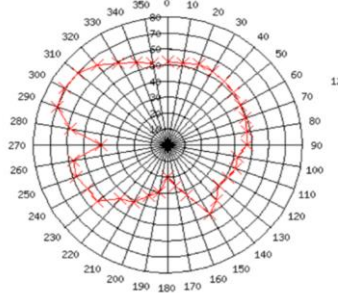
Cut out or opacity fade



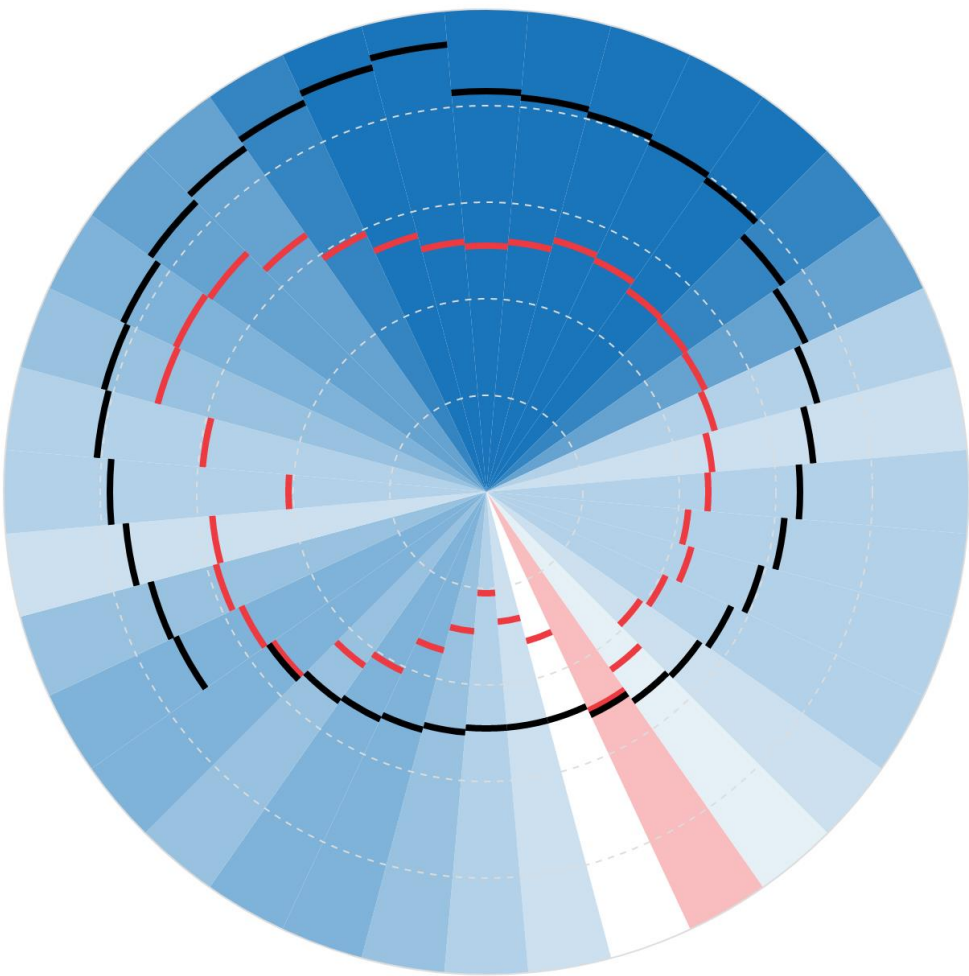
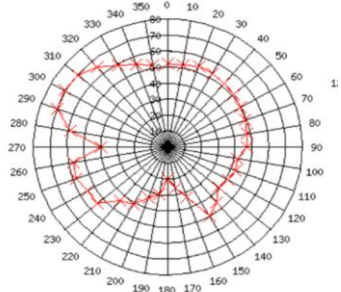
GTP

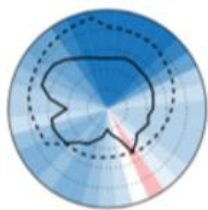


EMP



**LINK
MARGIN**





A



B



C



D



E



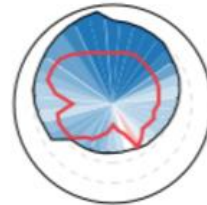
F



G



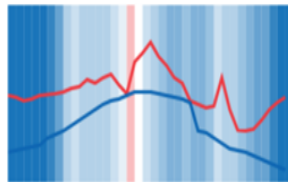
H



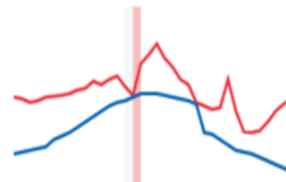
I



J



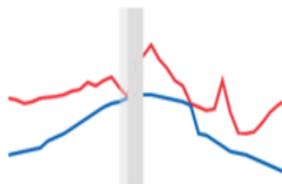
K



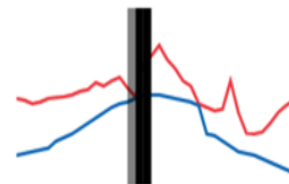
L



M

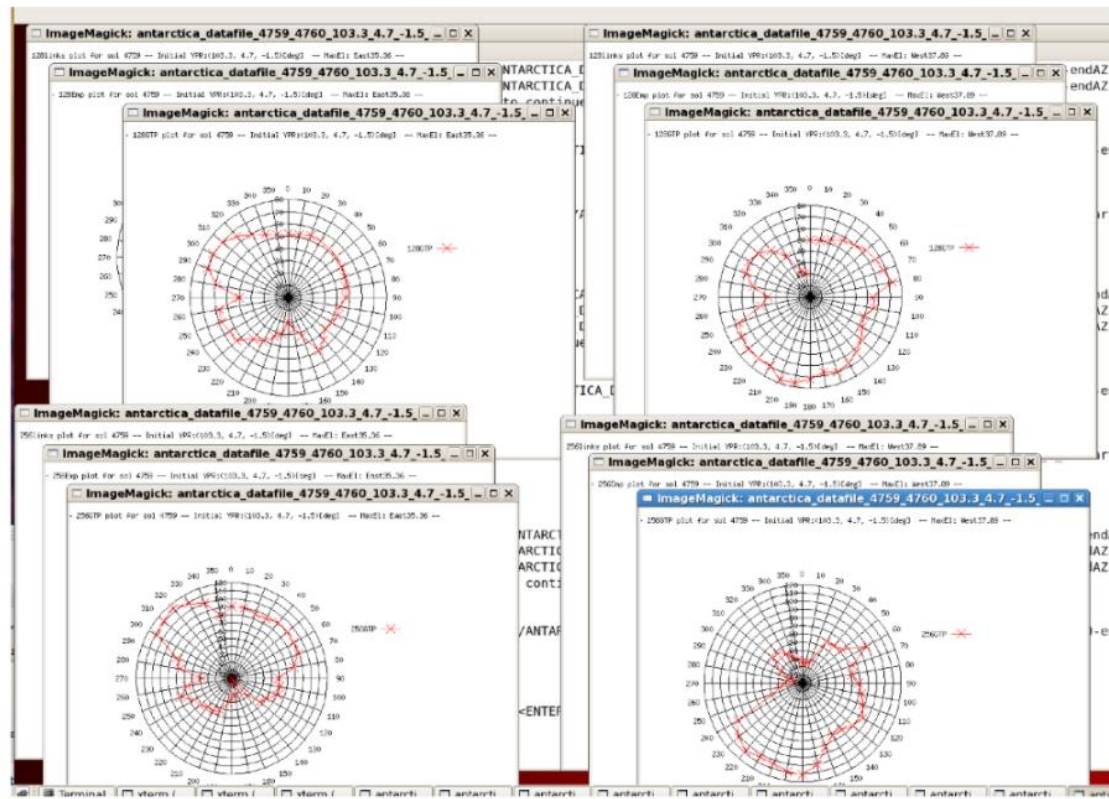


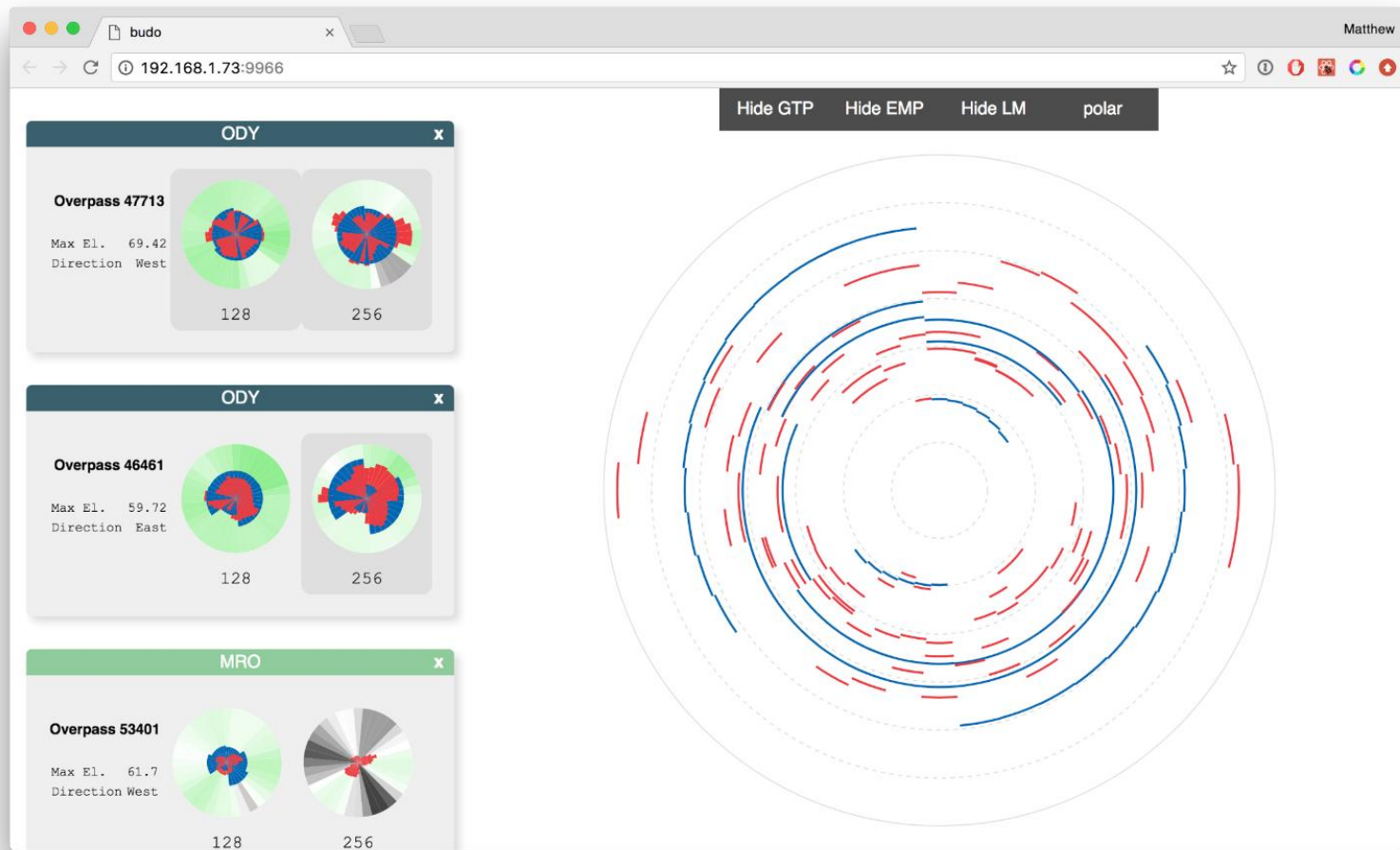
N

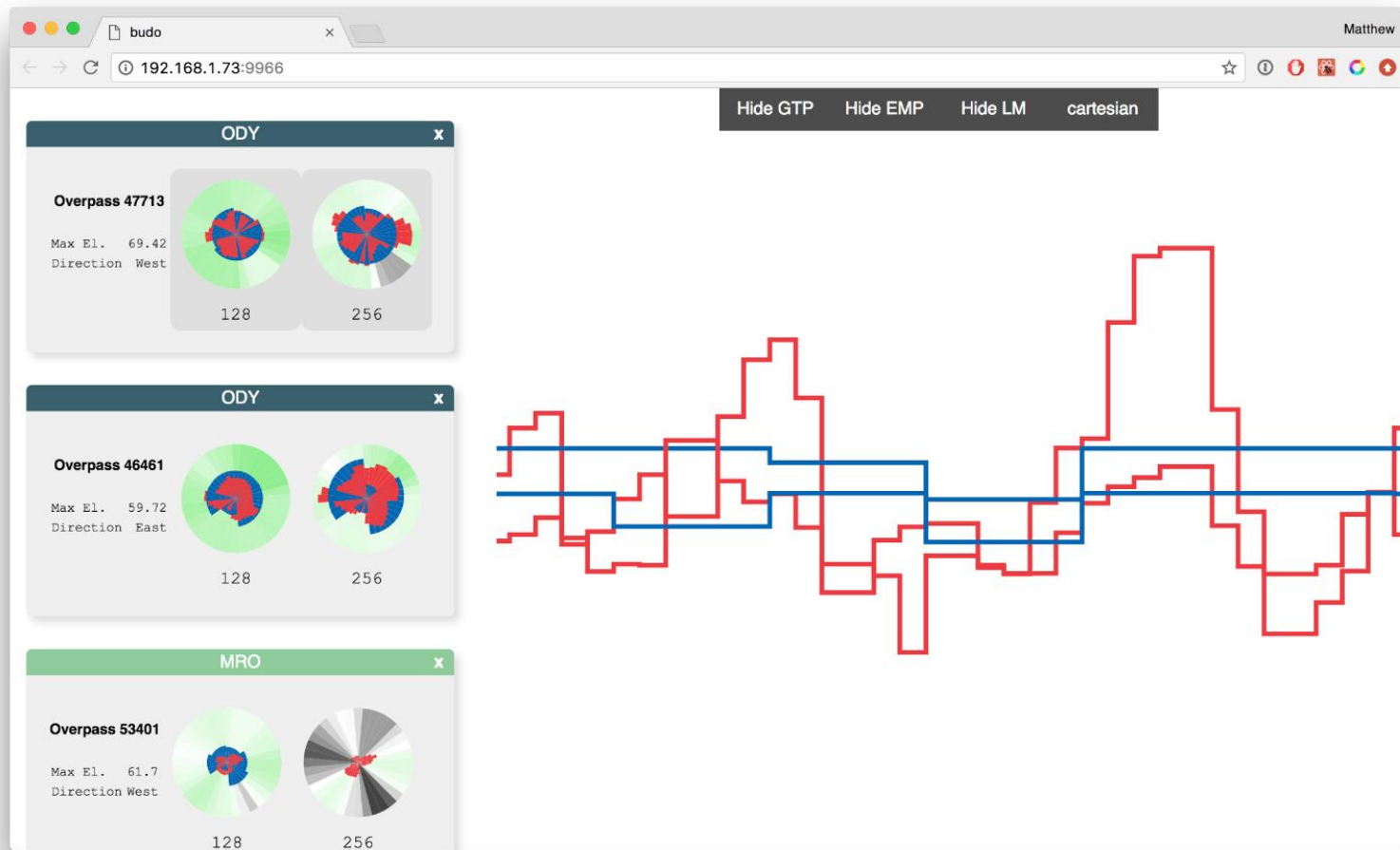


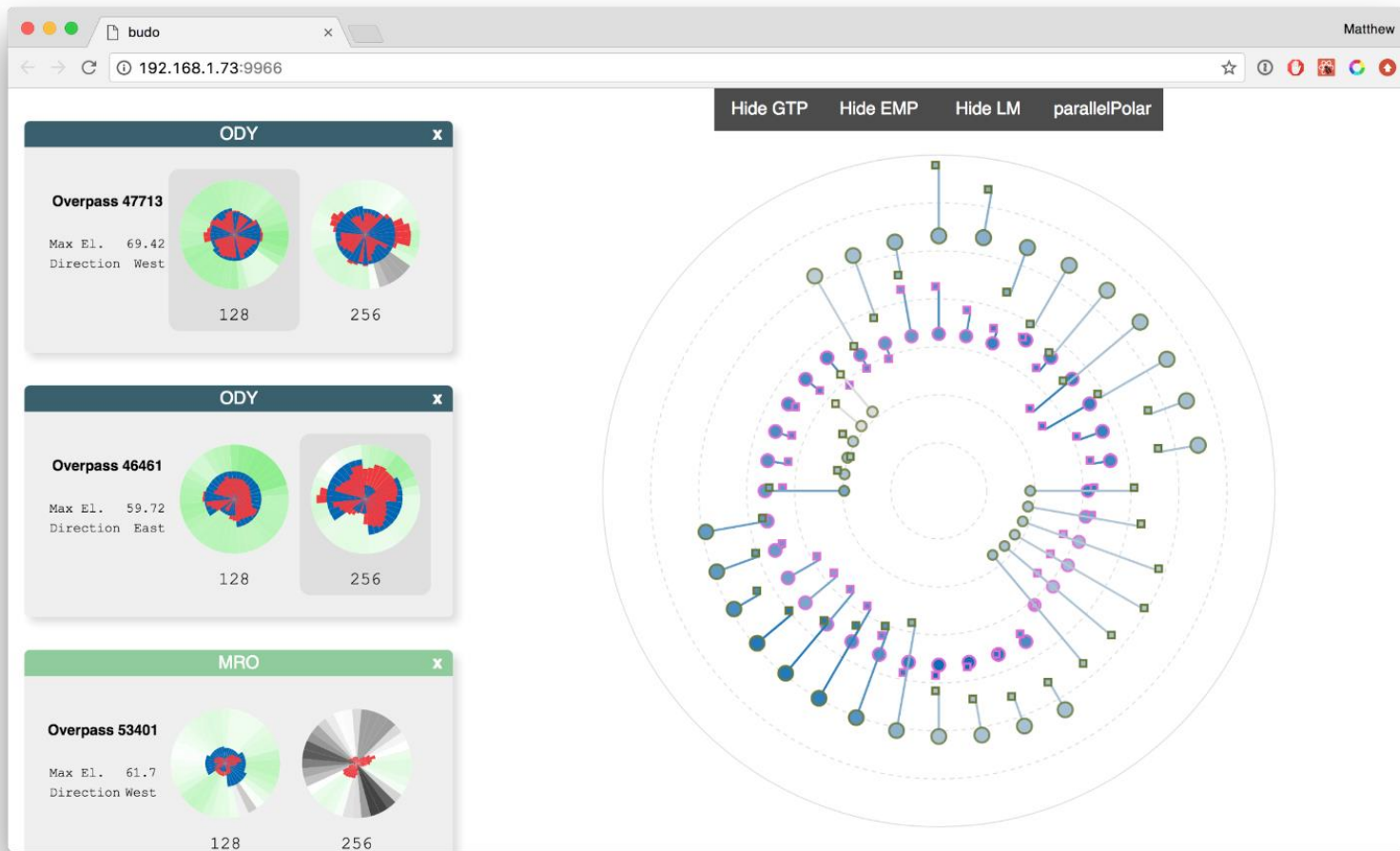
O

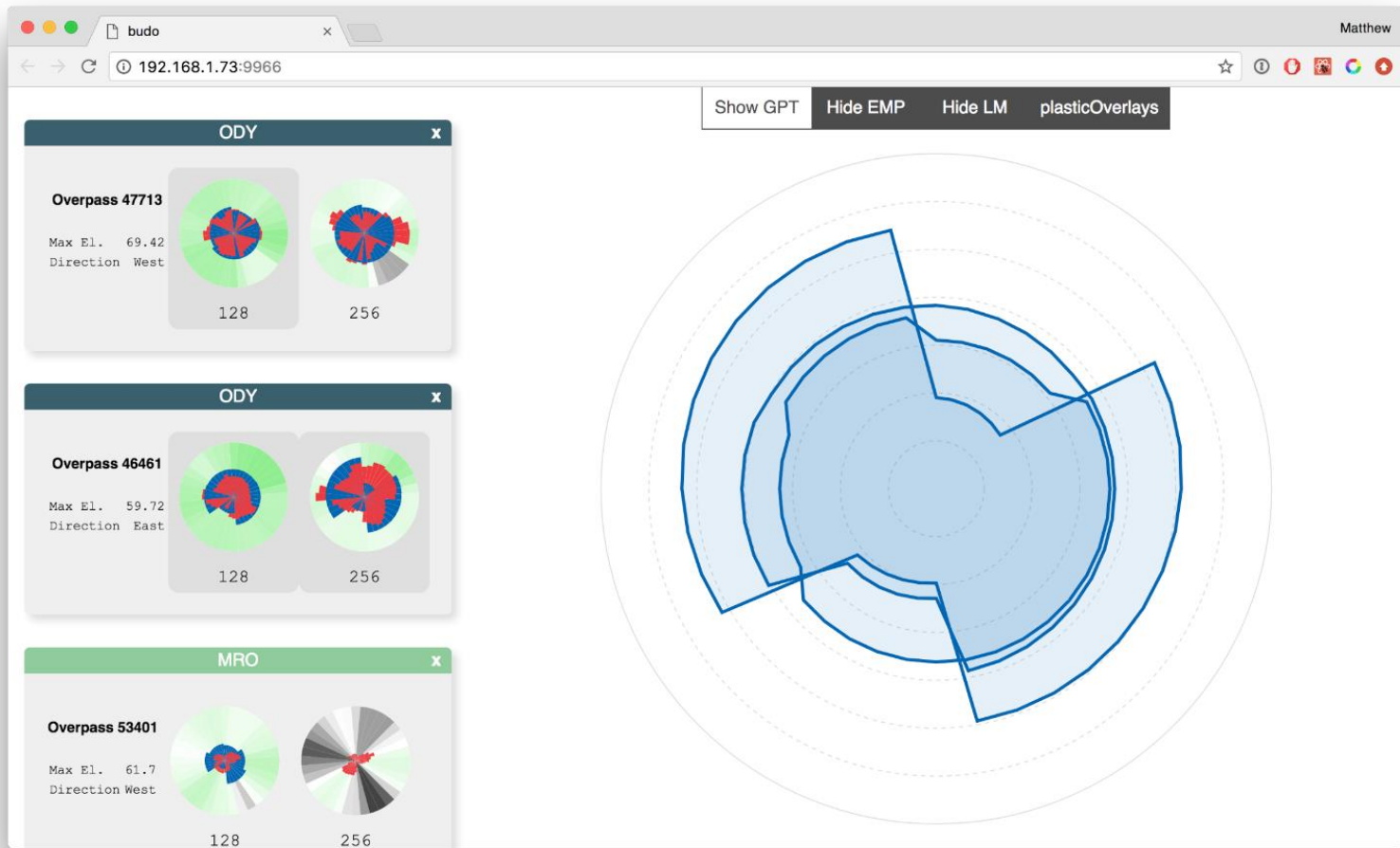
BUT, WE STILL HAVE TO WORK WITH THIS

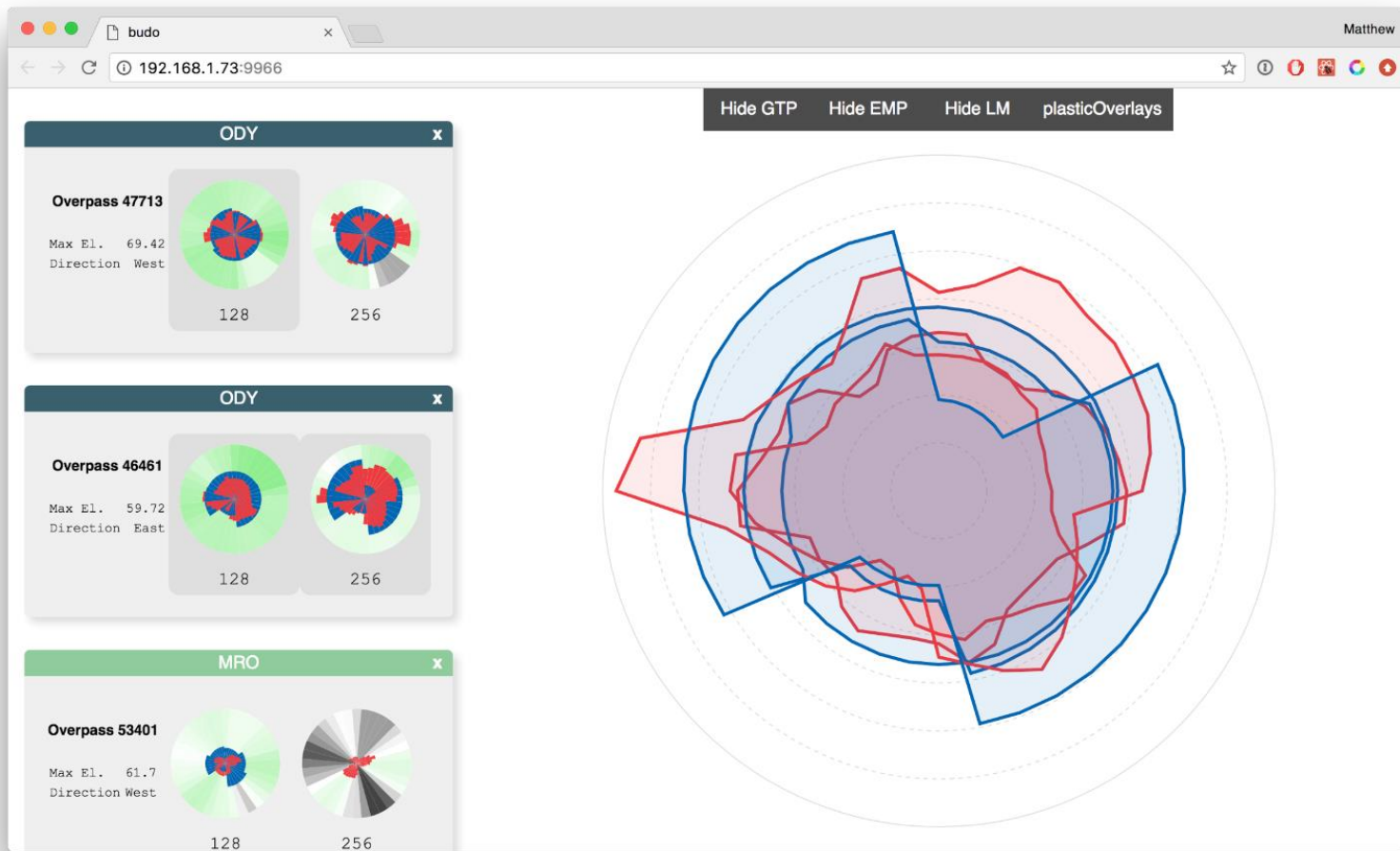


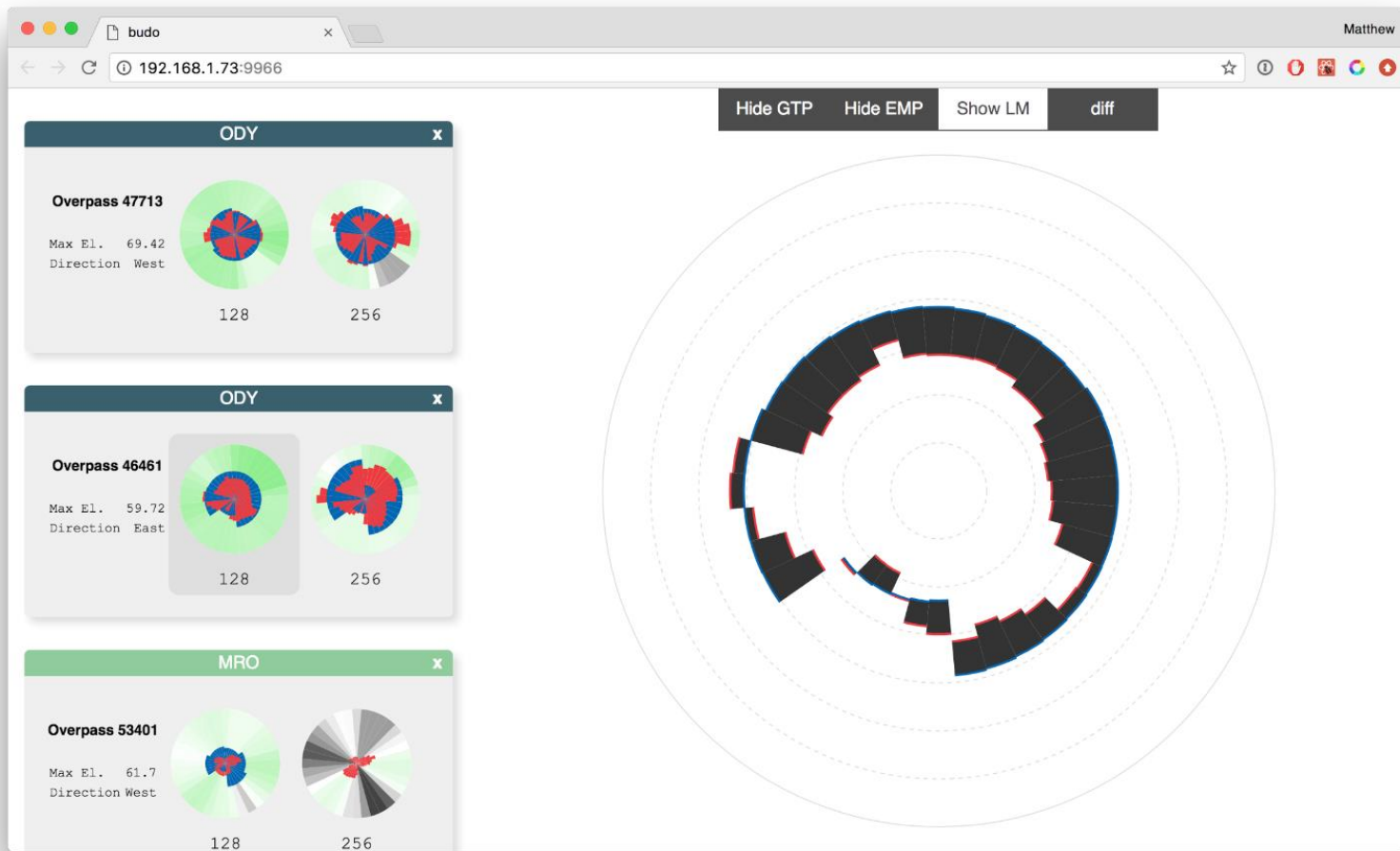


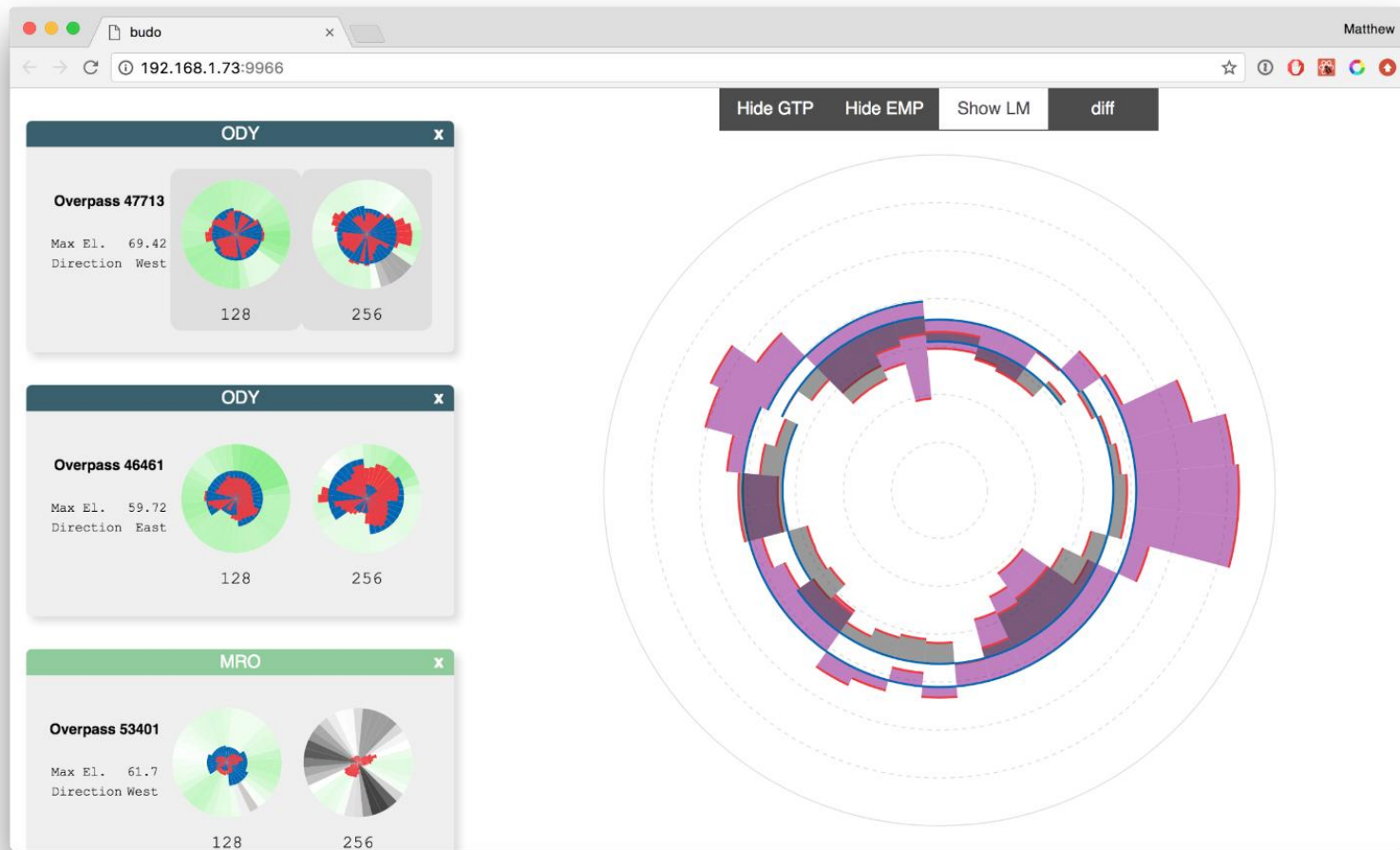


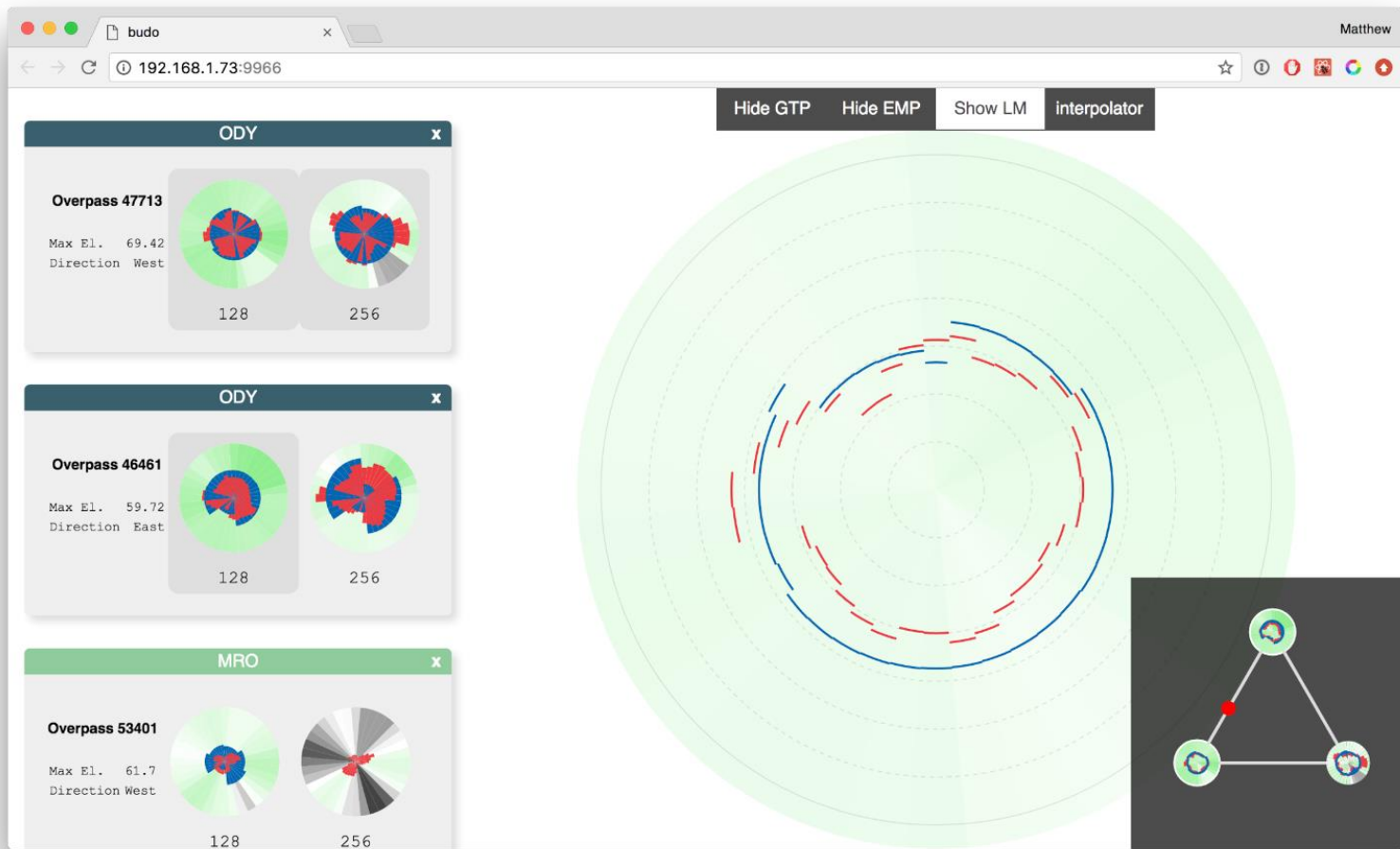


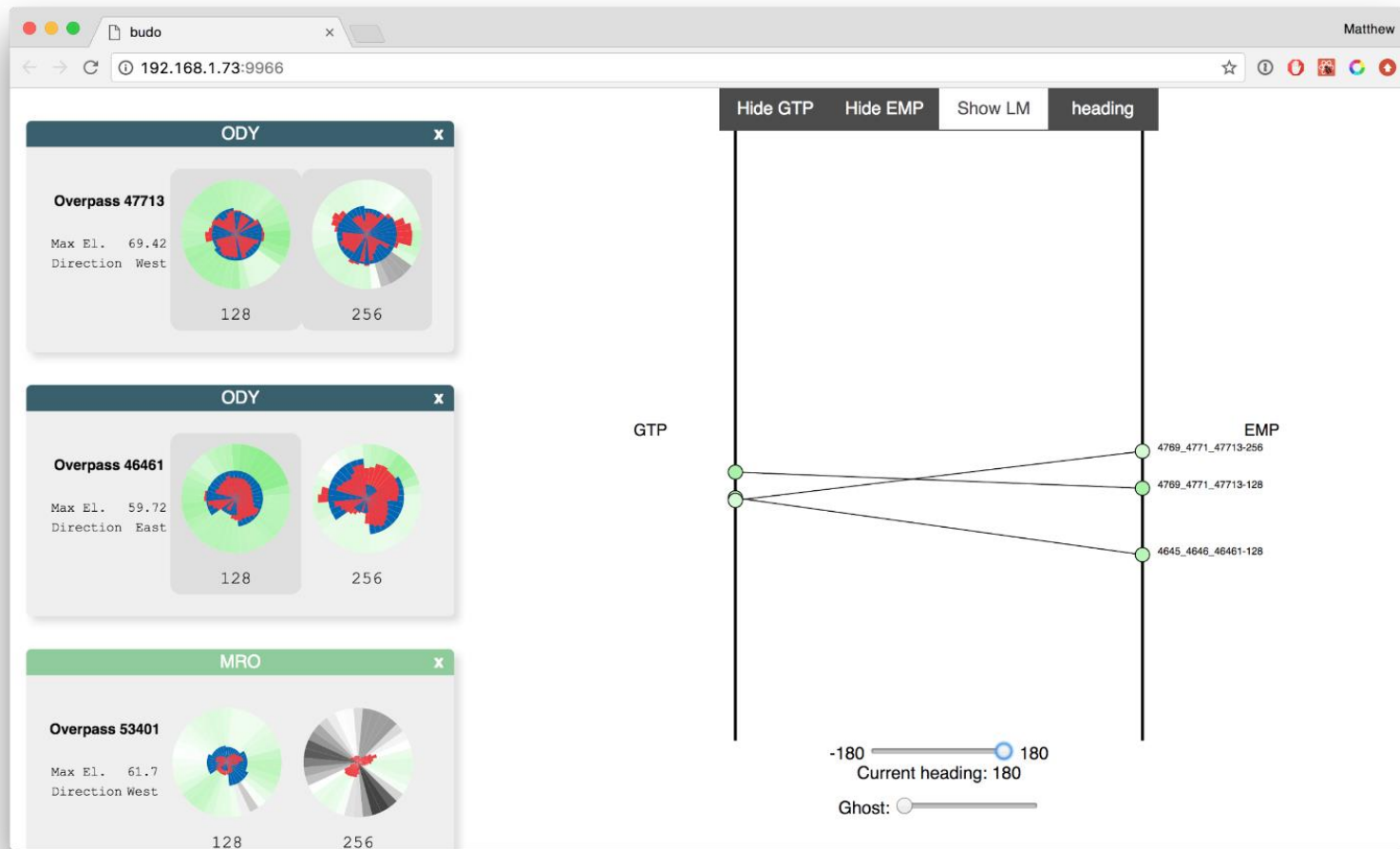


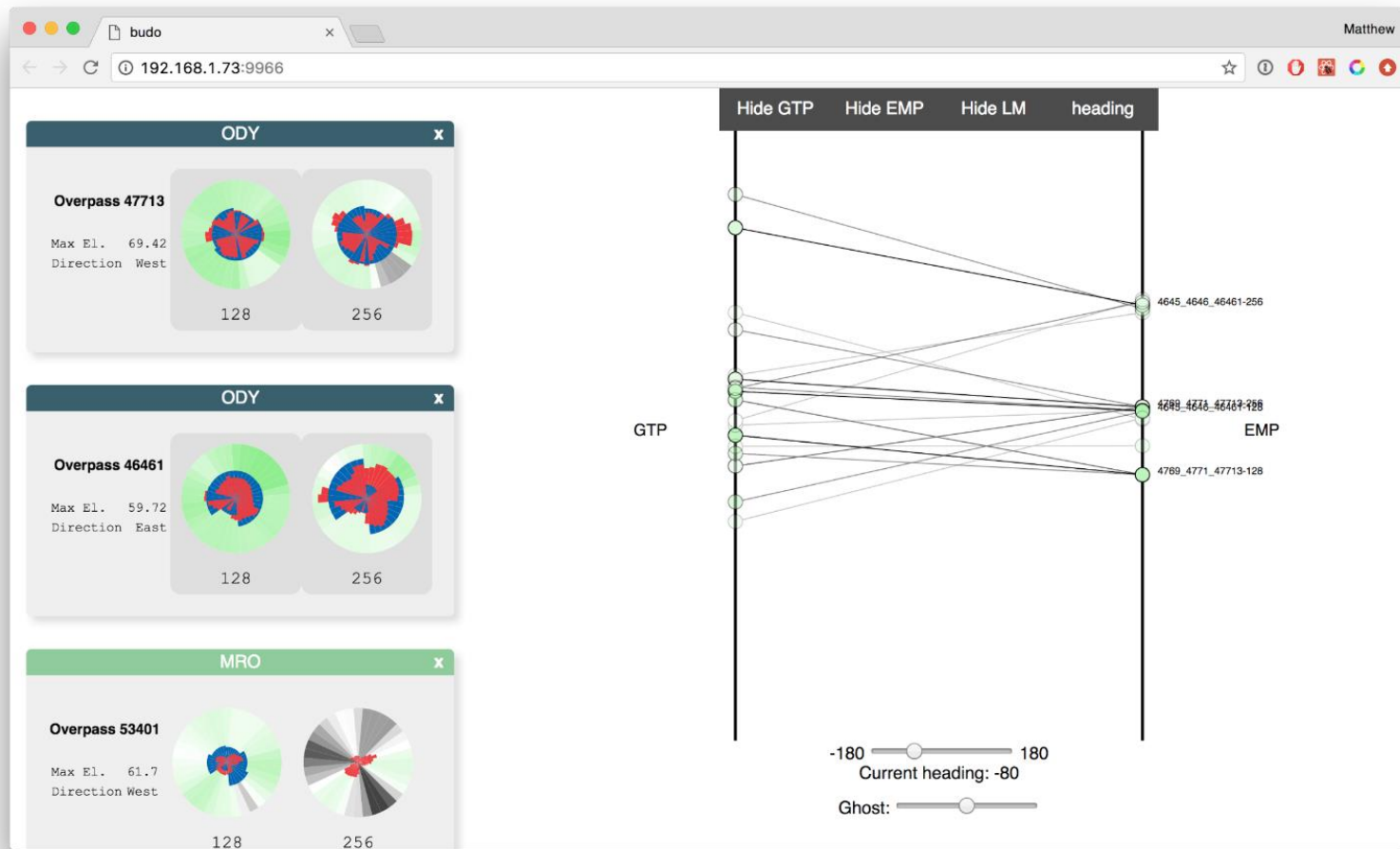


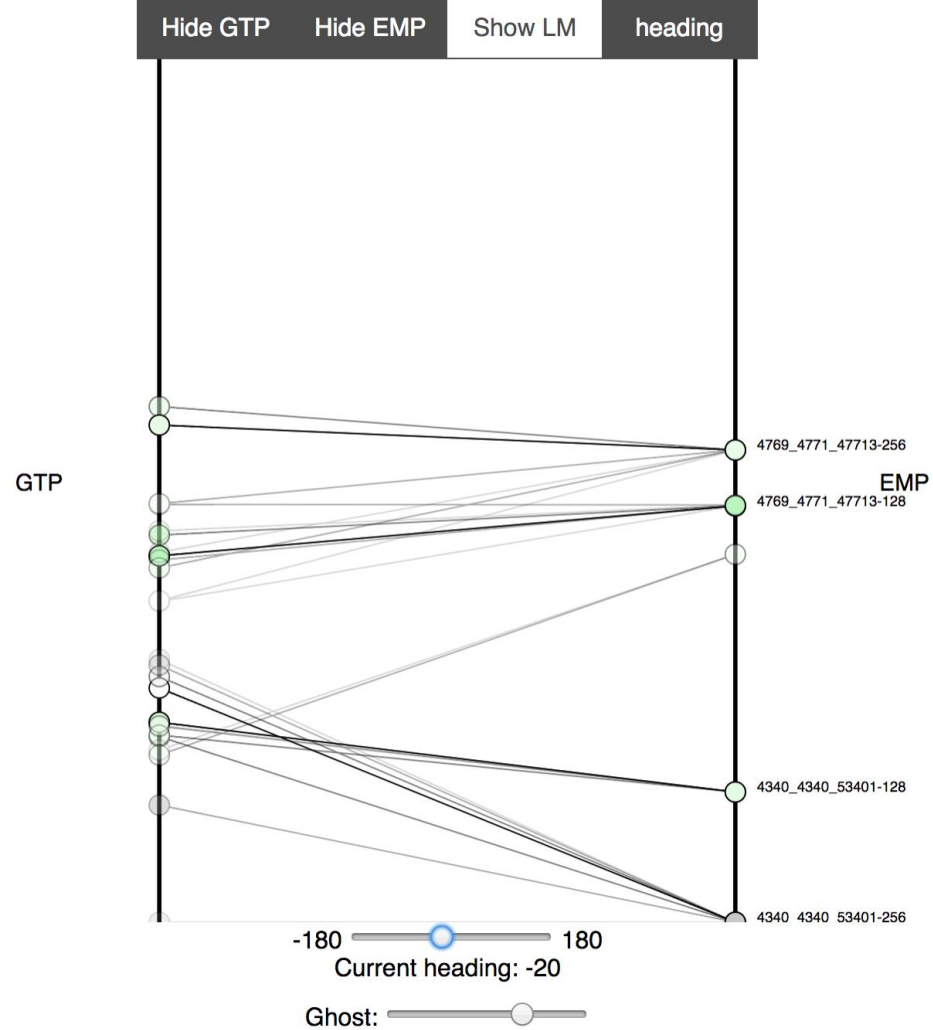




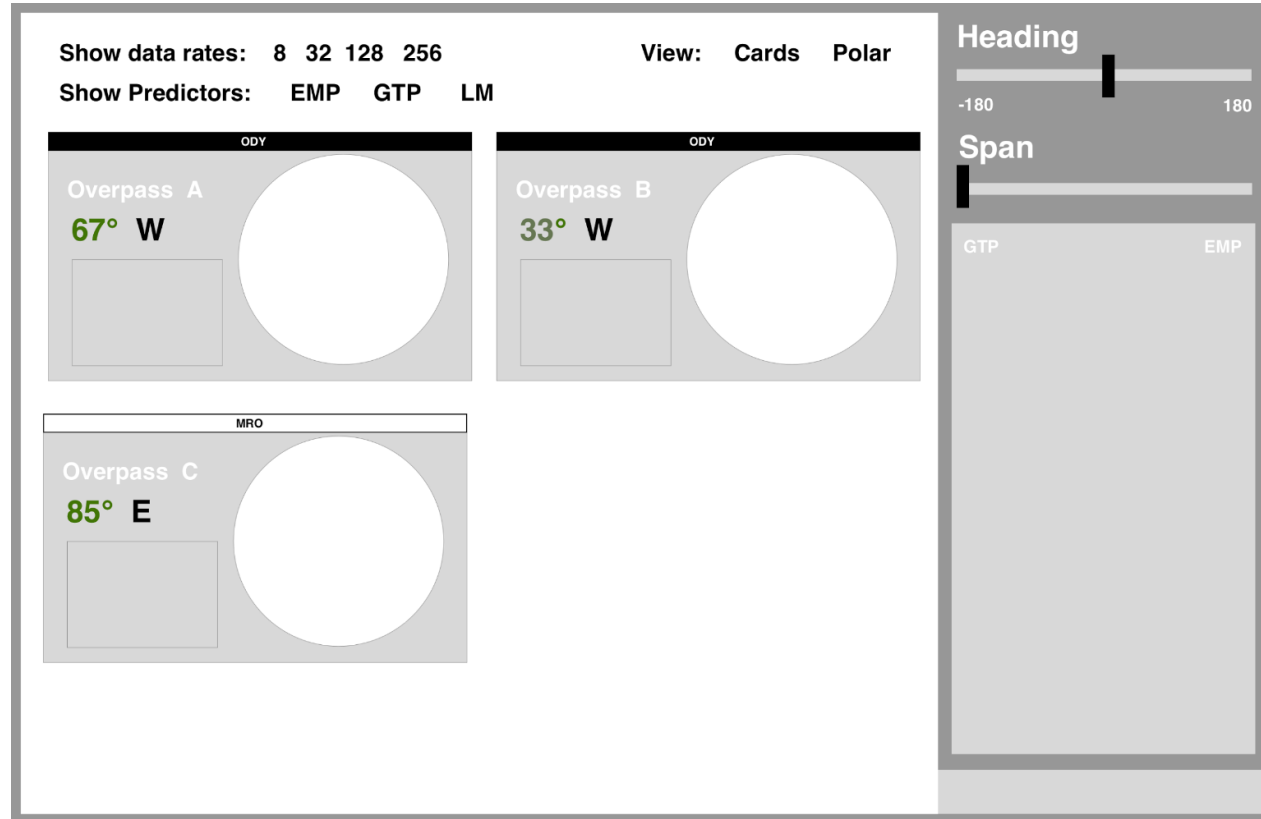








PAPER PROTOTYPING



Show data rates: 8 32 128 256

Show Predictors: EMP GTP LM

View: Cards Polar

67° W

33° W

E

Heading

100

100

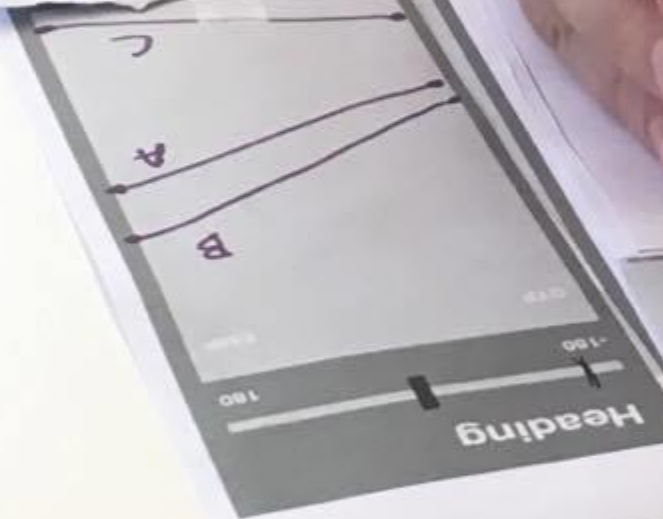
Span

ome! Enter the information below to telemetry estimates.

ading: 0

Data Rates:

Show Predictors:



View: Cards Polar

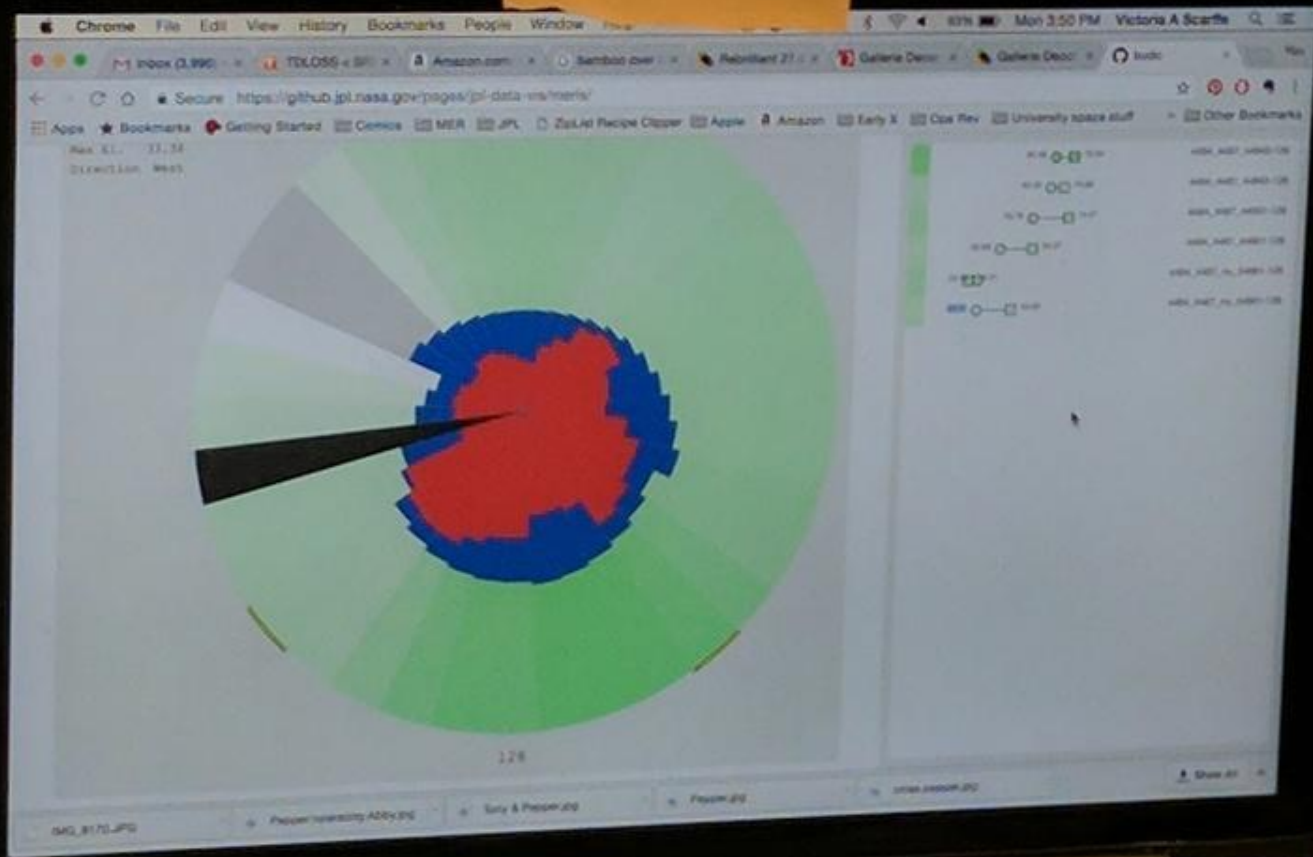
Data Rates: 8 32 128 256 LM

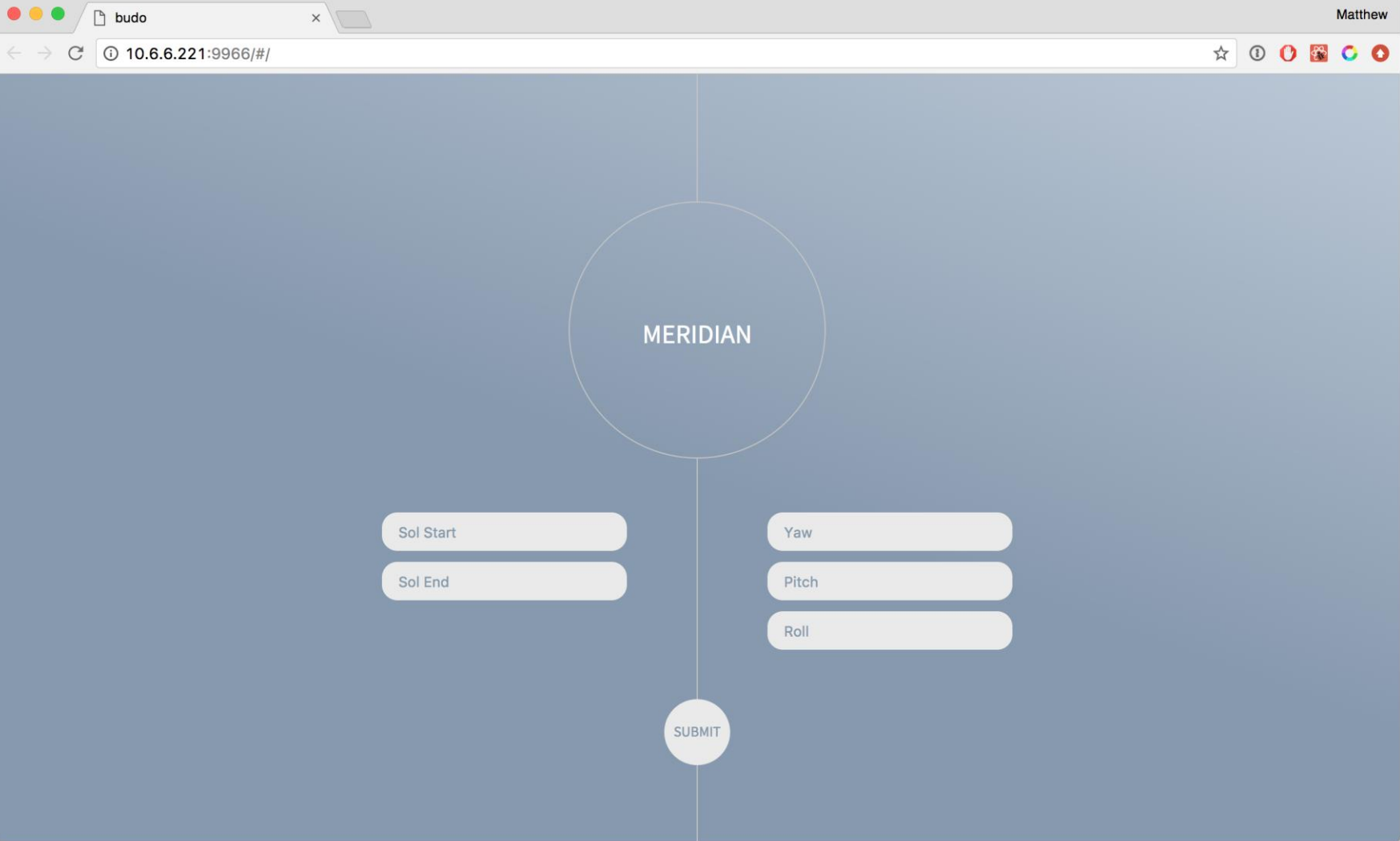
Show Predictors:

A B C

WZ







OUR SOLUTION

- 01 A centralized web interface
- 02 Organized, hierarchical info
- 03 Easy to download and send to colleagues
- 04 Plan in place to deploy with MER team

TECH

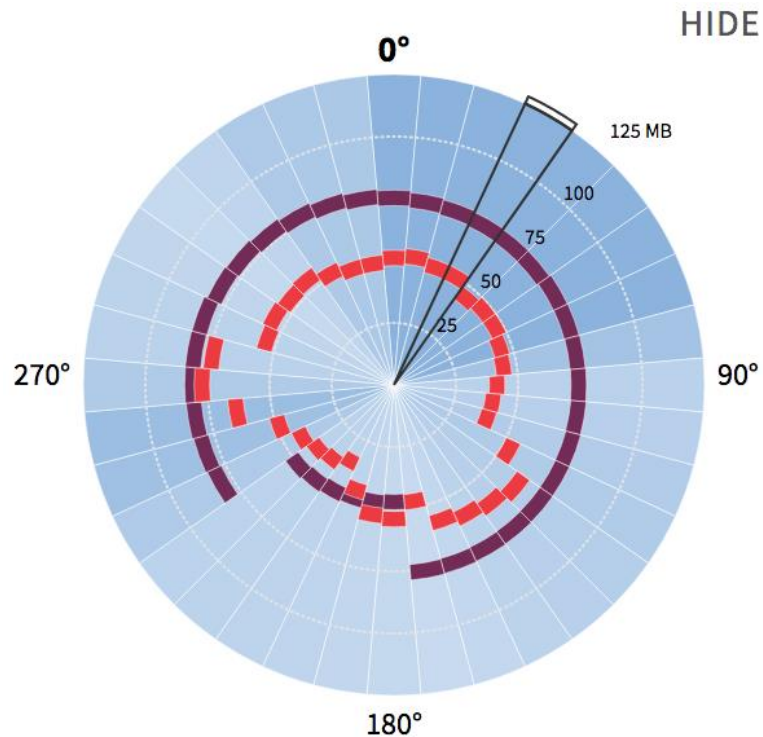
Budo development server

Flexbox for layout

D3 for scales, calculations, colors

React for state & view management

Developed reusable components



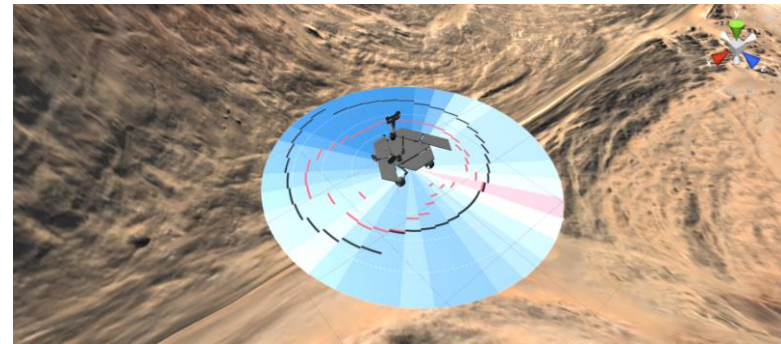
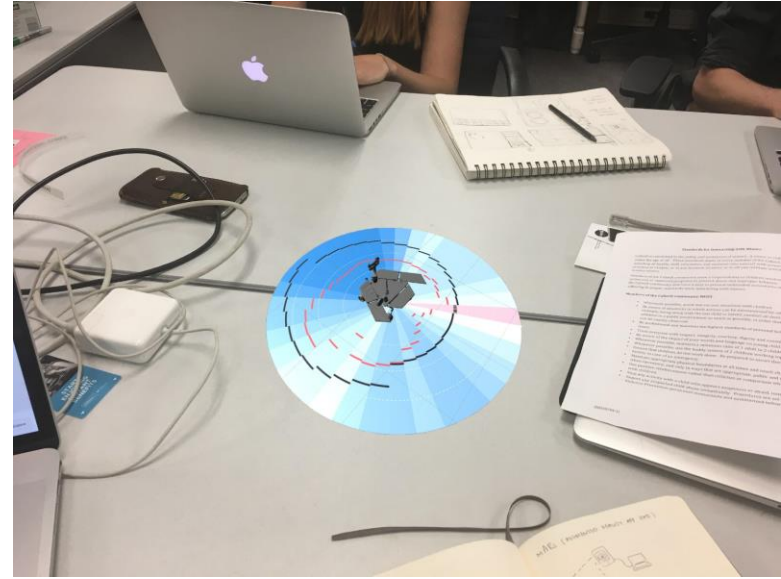
FUTURE WORK

Integration into other systems *Quill*, 2020, etc

Integration of the rover itself in terrain mask

Mobile

3D environment



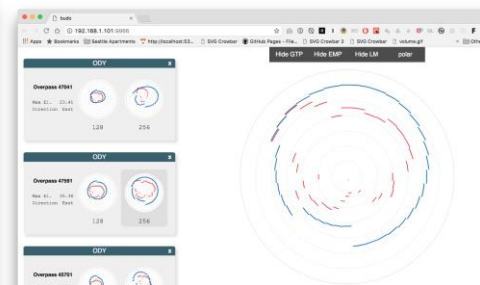
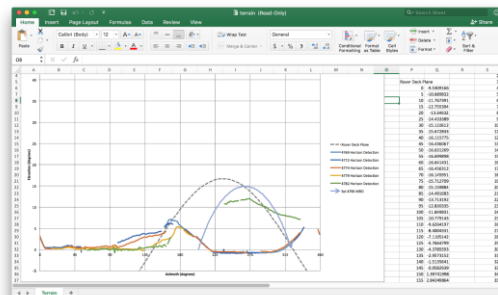
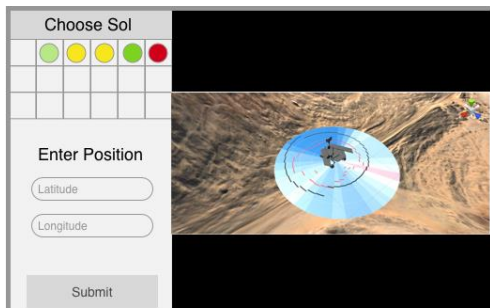
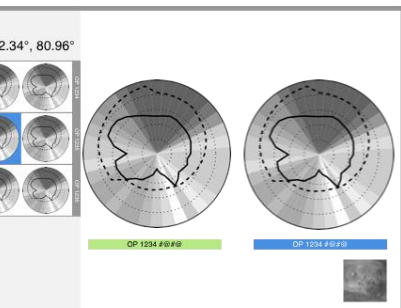
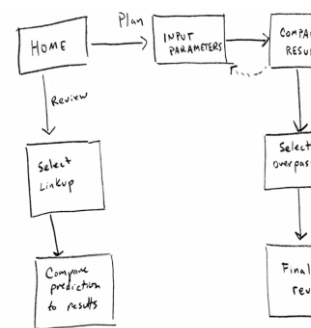
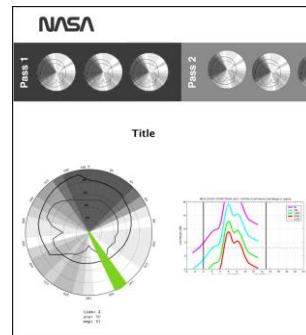
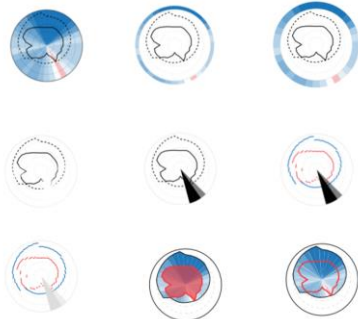
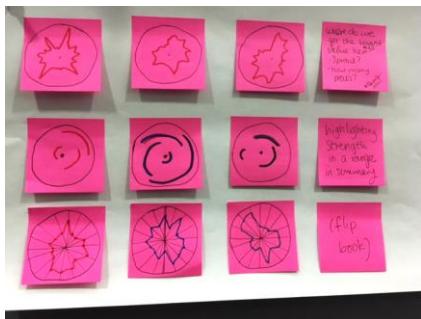
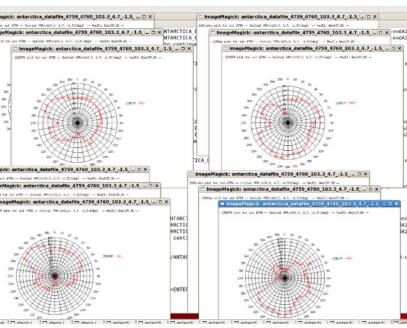
THANK YOU

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